Buying—POWER—*Section*

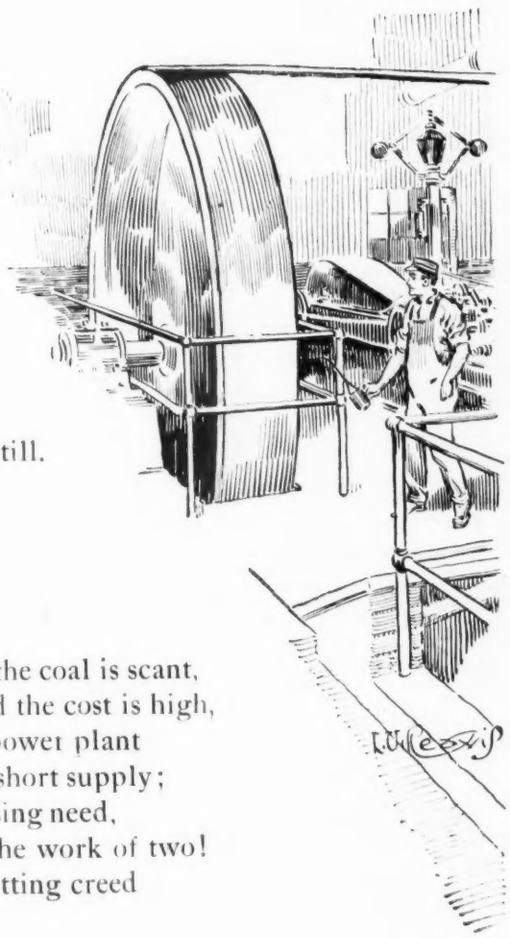
POWER

Volume 48 New York, September 3, 1918 *Number* 10

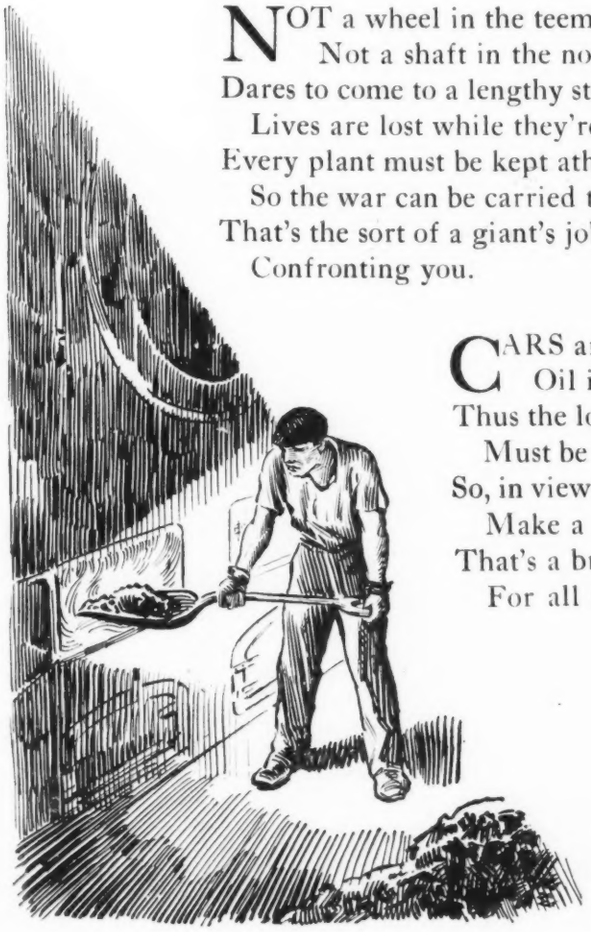
The Giant's Task

By Rufus T. Strohm

YOU who toil where the fires gleam
Dazzling white in the sweeping draft,
You who serve where the rushing steam
Spends its force on the engine shaft,
Industry in this pregnant hour
Looks with hope to your patient crew,
Knowing well that the needed power
Must come from you.

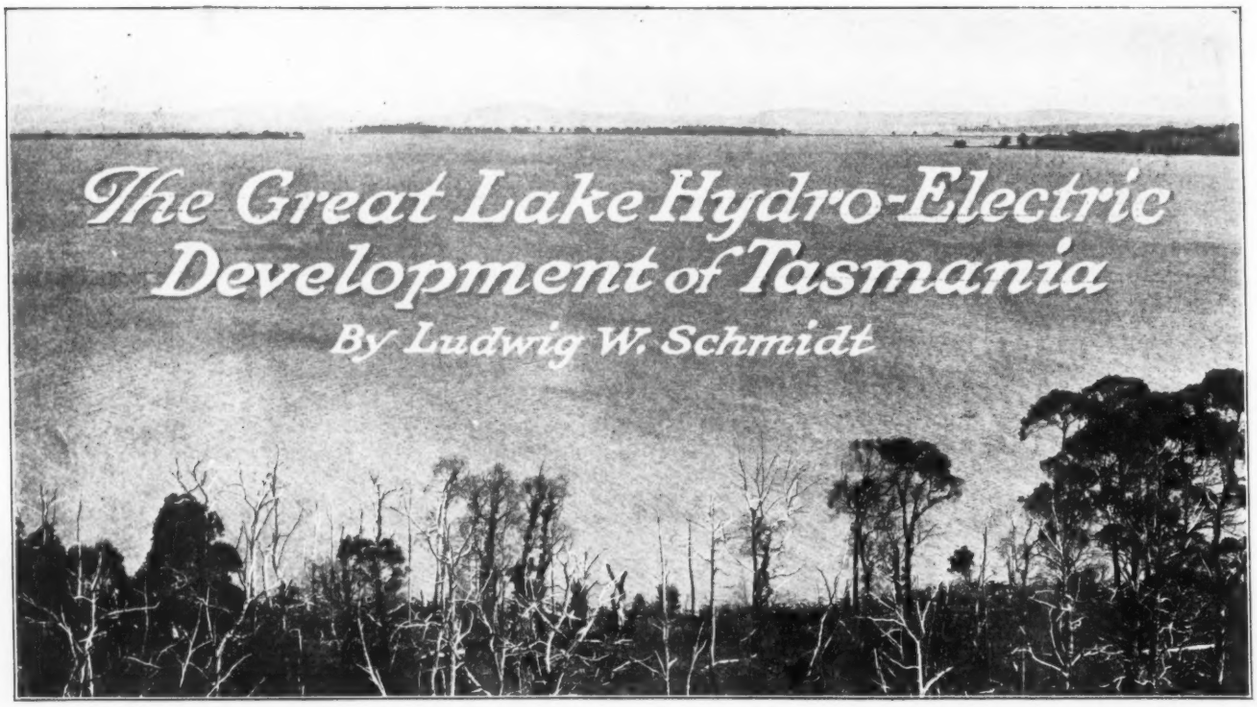


NOT a wheel in the teeming shop,
Not a shaft in the noisy mill
Dares to come to a lengthy stop—
Lives are lost while they're standing still.
Every plant must be kept athrob,
So the war can be carried through;
That's the sort of a giant's job
Confronting you.



CARS are few and the coal is scant,
Oil is scarce and the cost is high,
Thus the load on the power plant
Must be met with a short supply;
So, in view of the pressing need,
Make a pound do the work of two!
That's a brief and a fitting creed
For all of you.

SPARE no pains in the fight to save,
Put an end to the glaring waste;
Hope is strong, but the times are grave,
Haughty yet is the foe we've faced.
Though the road that you tread is rough,
Hard the task you are called to do,
Show the world there is hero stuff
In each of you!



A description of the most striking features of a 100,000-hp. hydro-electric development that was undertaken by private enterprise and completed with the financial aid of the government of Tasmania.

IF AN engineer had undertaken to construct an island with the express purpose of making it available for future hydro-electric development, he could not have done better than nature when she made Tasmania. Here is an island having just in its center on a high elevation a lake sufficiently large to provide its industries with all the electrical power that may be needed for some time to come. Unfortunately for the development of this ideal site, it is situated in one of the wildest regions of Tasmania. No railroads lead to it, and when the work began the nearest approach was over a road that never came nearer to the development than seventeen miles. Besides, the road was not much of a road, as the engineers found when they started to use it for the transportation of heavy machinery. Whoever built it had forgotten to supply it with a bottom, and wagons and machines too often sank into its depths and could be recovered only after many hours of hard work. From the road to the development a narrow-gage railroad had to be constructed. It was run through a rough country and in many places was laid on the unbroken surface of the ground. From the power station to the lake another railroad was built.

It is therefore no wonder that the cost of developing the site was very large. In fact, the first company that undertook the work ran out of money. Difficulties of construction and transportation were so great that it became necessary to increase the capital the promoters had intended to spend on the enterprise. Unfortunately for those interested, this stage in the development was reached at a time when money was most scarce in London and Europe generally, and so the question arose whether the undertaking should be postponed and completed at a more favorable moment, or whether it would be advisable for the Tasmanian government to step in and save the situation by completing the construction. The original promoters had done excellent work. They had carried the enterprise ahead as much as had been possible with the means at hand, and the engineers who reported to the government on the advisability of a continuation of the enterprise strongly recommended such a step. Building was continued by the Tasmanian government, which acquired the good will and existing works from the first company, and the whole scheme finally was completed during the year 1916. Tasmania in this way has opened a power source that is able to produce as much as 100,000 horsepower.

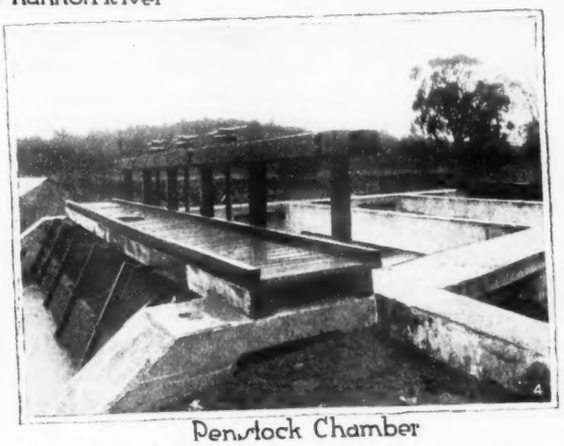
The basis of the whole system is the so-called Great Lake, which is shown in the headpiece. With its catchment area of 216 square miles and its water area of 50 square miles it forms an ideal foundation for a great hydro-electric enterprise. A dam that has been constructed on the southern outlet of the lake provides for an even depth of 11 ft. above sill level, and experience has proved that this will be sufficient to guarantee a regular flow of water. Experiments made during the first year of operation have shown that during a year of normal rainfall a total of 70,000 hp. can be obtained easily from the lake. After five months, when an average of 60,000 hp. had passed the weirs, it was found that the level of the lake was standing considerably higher than before that period. Test figures have shown that 12 cu.ft. of water on the dam will be sufficient to generate 1000 hp. at the turbines.

By way of an outlet in the dam, shown in Fig. 1, the water of the lake enters the river bed of the Shannon. Farther down the river a weir and intake are provided, as in Fig. 2, to lead the water from the river into the canal, shown in Fig. 3. This canal is designed for a capacity of 2000 hp. The actual fall

Dam on Great Lake

Intake on Shannon River

Canal Leading to Reservoir



Penstock Chamber

Wood-Stave Pipe Line

Steel Pipe Lines

Power Station and Tail Race

of 65 ft. is broken by a series of special drops, each 30 in. in height, constructed in the bed of the canal, at frequent intervals. The total length of the canal is 3½ miles.

Chance has provided at the end of this canal for one of the most important features of the whole undertaking; namely, a special reservoir to support and augment the principal reservoir of the lake. This reservoir is formed by a natural depression in the ground. Here a water pool of considerable size used to collect in wet weather, but it vanished completely during the dry season. The engineers decided to make use of this depression to provide an additional safeguard for a regular water supply. By means of three earthen dams of an average height of between 2 and 3½ ft. a water reservoir of 340 acres has been obtained holding the water at an average depth of 4 ft. The reservoir is a little over a mile long. To prevent too great a water pressure an overflow has been built to lead the surplus waters into the Ouse River. Today the dams of the reservoir stand about 18 in. above the water level. Should it become necessary to obtain a larger water reserve, the dams can easily be raised. The principal advantage of this reservoir is that it will allow the water supply coming from the lake to be shut off while the dams and canal are being repaired, without interfering with the working of the power plant, which for the time being can be well served by the water accumulated in the second reservoir.

A penstock chamber, shown in Fig. 4, connects the reservoir with the pipe lines. This chamber has been constructed to hold a double line of pipes, but at the beginning only a single 4-ft. wood-stave pipe was used, as in Fig. 5. A second wood-stave pipe has been laid only recently. To insure a permanent flow of water the top end of the pipe is placed in the penstock chamber at a sufficient depth to secure a minimum of at least 10 ft. of water above the entrance to the pipe. The pipe consists of 21 staves held together by ⅜-in. steel bands. Relief valves have been fitted at intervals, and to prevent a vacuum a 30-in. standpipe was erected. The wooden pipe is 5500 ft. long and is supported on logs cut from the surrounding forests, its own weight being sufficient to hold it in place. An anchor is used only at the end of the wooden pipe line where it is connected to the steel pipes. The wooden pipe has proved a success, as it is absolutely water-tight and withstands the climate well.

The remainder of the line consists of two steel pipes, Fig. 6, made in three equal sections running from 37 to 27½ in. internal diameter. The connection with the wooden pipe is secured by two sluice valves, and sixteen anchors were needed. The foundation of the steel pipe lines is of masonry or concrete. Each steel pipe is 4300 ft. long, giving a total length of pipe line of 9800 ft. from the second reservoir to the power house.

The two steel pipes are now to be supplemented by a third one of wood, wood in this case being used owing to the difficulty of obtaining steel. It will be a 49-in. pipe designed for a maximum pressure of 204 lb. per sq.in. The wood used is eucalyptus, and the complete pipe will have a capacity of 16,000 hp. Pending the completion of the wooden pipe, a smaller steel pipe of a capacity of 8000 hp. has been laid to allow a new unit to be put into service immediately.

The power house of the development lies in the center of a valley close to the River Ouse, as shown in Fig. 7. The station is of steel-frame construction, covered with corrugated iron sheeting and may be replaced in future by a more pretentious building. Two turbo-alternators were installed in the beginning, but two other complete units having a capacity of 7050 kv.-a. have been ordered, and will be installed immediately on arrival. The pipes are joined before reaching the station, and part of the water is withdrawn for working the exciter and the auxiliary turbines. The original turbines were of the horizontal Pelton-wheel type running at a speed of 375 r.p.m. and rated at 4980 hp. Each turbine is connected directly to a 4050-kv.-a. three-phase alternator generating at a pressure of 6600 volts. The current is led from the transformer switches to two banks of transformers, each bank having a normal capacity of 4050 kv.-a., and a maximum half-hour capacity of 6000 kv.-a. The transformers step up the pressure from 6600 volts to 88,000 volts. The whole of the apparatus has successfully passed a pressure test of 120,000 volts to earth and 150,000 volts between phases. Apparatus to protect against lightning is provided outside the station. The water, after having passed the turbines, flows into the River Ouse.

Construction of the Transmission Line

Power from this station is supplied to Hobart, 62½ miles away, and to North West Bay, which is 15 miles farther south. The standard span of the transmission line is 600 ft., and the suspension towers are constructed to withstand a wind pressure of 30 lb. per sq.in. The strain towers will withstand the failure of all the conductors on one side. The height of most of the towers is 60 ft., but the special towers at the River Derwent crossing are 160 ft. high from the ground level to the earth wire.

The transmission line ends in step-down stations, one of which is erected at Newtown, near Hobart, to reduce the pressure from 88,000 volts to 6600 volts. Other substations are erected through the city, where further reductions are made for the ordinary power and light consumer.

The construction of the transmission line from Hobart to North West Bay differs from that of the main line in that wooden poles are used instead of steel towers. The suspension towers of that line are of the two-pole type, while the strain towers are of the A-pole type. Steel towers have been resorted to practically only at road crossings and at certain points where special construction appeared advisable. This line is terminated at the North West Bay substation.

The principal field of distribution of the development today lies in the City of Hobart and in the North West Bay, where industrial enterprises form the leading consumers. Only a small part of the total power obtainable, however, so far has been developed, and extensions are already contemplated. These will provide electric power for other parts of the island, which in this way gains a centrally situated power source of great importance. The fact that the Great Lake development has been taken in hand by the government adds largely to the usefulness of the enterprise, as there is little or no danger that the great natural power thus disclosed will run to waste.

Care of Pneumatic Temperature Regulation Systems

The general suggestions of instructions on the care of temperature-regulating systems given in this article were supplied by request by Kennedy Duff, manager of the New York office of the Johnson Service Company.

ON account of the present necessity of conserving the fuel supply of the nation, it is the duty of every operating engineer to make the best use possible of all apparatus that will cut down the consumption of fuel. It is universally admitted by engineers that a system of automatic temperature regulation saves fuel. The saving depends largely upon the condition of the apparatus, and in buildings where the engineer takes pride in things under his charge, the temperature-regulation system is likely to be kept in good order and the result is a large economy in fuel.

The thermostats open and close the radiator valves at the temperature at which they are set to operate, avoiding overheating, and the radiators cease to condense steam when the valves are closed. Plants that have been neglected should be repaired and put in order so that when the next heating season arrives they will be ready to go into service. The fuel saved will pay for the repairs many times over, and not only are they a good investment for the owner, but they will reflect credit on the engineer and, above all, will comply with the Government requirements to reduce the consumption of fuel to the minimum. It is not the intention in this article to explain in detail the care of any particular system of temperature regulation; the subject is treated only in a general way. A great many engineers are not thoroughly familiar with the thermostat and the other mechanism used in heat regulation, but in such cases the manufacturers are always willing and anxious to supply the necessary information to the engineers in charge.

Compressor Should Be Kept in Good Order

Pneumatic systems of temperature regulation are designed to operate with air pressures ranging from 12 to 15 lb. sq.in. Various types of air compressors are used, but whatever the design or make the compressor should be kept in good condition and free from leaks at gaskets, unions, checks, etc. Hydraulic air compressors are generally fitted with leather cups, and this type of pump should be lubricated about once every two or three weeks. Sperm oil only should be used, as other oils cause the cup leathers to stick in the cylinders and also tend to crack the leathers. Air-compressor cylinders should be given a small quantity of oil at regular intervals, for if a large amount of oil is supplied at random there is a possibility that the oil will be carried up through the check valves into the air piping, causing the checks to stick or become leaky and fouling the pipe lines. The check valves should be cleaned at least once every season and should be fitted with new check seats whenever necessary.

It is best to start hydraulic pumps at the beginning of the heating season and let them run continuously until the heating plant is shut down the following spring. However, in public buildings where the heating systems are shut down over night, week ends and holidays, and where water is expensive, the pumps should be shut down with the heating system by turning off the stop-cock in the air-discharge line at the top of the pump rather than by shutting the valve in the water-supply line to the pump. Shutting the pump down in this manner shows whether the air cylinder of the pump is tight or not, for if any leakage takes place in the air cylinder or check valves, the pump will continue to run so that the cup leather in the air cylinder should be spread and oiled or, if necessary, renewed; or the check valve should be given attention.

Stopping the Compressor

When the heating plant is shut down for the summer, the air compressor should be stopped in the same manner described or the valve in the water line to the pump can be closed if the main and auxiliary water valves are removed and thoroughly wiped off and saturated with sperm oil, at the same time thoroughly lubricating the plunger leathers in the pump cylinders. This oiling will prevent the leathers from drying out during the summer. Where there is danger of the pump freezing when the heating plant is closed down temporarily, the water supply to the pump should be closed off and the lines and the pump should be drained to prevent breakage. The diaphragm in the water-reducing valve, controlling the supply of water to the pump, should be kept in good repair, but no oil should be used on it, as it will invariably work through and rot the rubber diaphragm. Where the water pressure is high, the reducing-valve diaphragm should be renewed at least once every season, but where low pressure is available these diaphragms will usually last through several seasons. They should be renewed whenever the slightest leak occurs, otherwise the valve springs will soon become rusted out and there is also a possibility of the diaphragm bursting.

Oiling Electric Air Compressor

Electric air compressors should be oiled with a good grade of mineral engine oil. The cylinder-oil cups should be filled about once a month. Too frequent oiling may result in the oil being carried over into the air reservoir and from there into the lines to the thermostats, which will result in considerable trouble. The crank case should be drained and flushed with kerosene and refilled with new oil once every season. The motors should be kept in good condition, special care being given to the brushes and commutators. Contacts on governor switches should be kept clean by the occasional use of sand paper. Never use emery cloth or emery paper on governor contacts or motor commutators. The electric governors should be set to operate at a variation of not less than three pounds pressure. Closer adjustment causes unnecessary wear of the motor and

governor by too frequent starting and stopping. The check valves should be thoroughly cleaned at least once each season.

Steam air compressors require the same general care given to all types of steam pumps, but as already cautioned the air cylinders should not receive much oil. Governors should be kept in good condition and should be set to operate on a variation of not more than two pounds in order to have the pump operate at frequent intervals, thereby tending to keep the steam line free from condensation. The pump should be thoroughly overhauled and repacked during the summer months when the system is shut down.

Inspecting the Regulating System

Before the heating system is started up each fall, the regulating system should be inspected, and where rubber diaphragm valves and damper motors are installed, new rubber diaphragms should be placed where necessary and a few drops of oil should be placed on the valve stems. Where stuffing-boxes show evidence of a leak, the packing nut should be slightly tightened and the valve should then be tested. Should the leak continue, the valve should be repacked. Care should be taken not to tighten the stuffing-box nut too much as this will cause the valve stem to bind or stick. All unions or couplings connecting the air piping to diaphragm valves should be inspected at least twice each season and tightened where necessary, especially where pronounced expansion takes place in the radiator branches, as the constant straining tends to cause leaks at these points. Where the steam piping is so run that the valves are practically stationary, it should not be necessary to tighten these connections oftener than once every two or three seasons. If the air lines are kept tight and the diaphragms in valves and damper motors are kept in good condition, no trouble will be experienced in maintaining the proper air pressure. It can readily be seen that if a leak develops in a branch air line to a diaphragm valve, the full pressure will not be exerted on the valve disk and the valve will not be steam-tight.

Inspecting and Removing Valve Disk

Every few seasons it is well to inspect the composition valve disks and renew them where necessary. Mixing dampers controlled by graduated acting thermostats should be so adjusted that the spring tension on the damper motor will permit the damper to be fully closed when the pressure on the diaphragm is approximately 12 lb. If the spring tension is too weak, the dampers will close too quickly and open too slowly, thereby losing the desired graduated action. Thermostats should be inspected and, where necessary, adjusted at the beginning of each heating season. Whenever a thermostat is removed for repairs, the air main leading to it should be thoroughly blown out before it is replaced. On installations where part of the thermostats are used to control the heating system and others are for use in connection with refrigerating plants, driers, hot-water generators, etc., the air piping is generally arranged so that one main air line supplies the thermostats for the heating system, and another main air line supplies the ones in operation throughout the entire year. Where this condition exists, the air should be shut off the main supplying the thermostats for the heating system at the time the heating plant is shut down to eliminate condensation which may develop during the idle period.

The main air-suction line for the air compressors should be run to a point outside the building where clean, dry air can be obtained. The end of the line should be fitted with a fine-mesh screen and lined with felt or cotton, which should be renewed every three or four years. Each reservoir is fitted with a pet-cock in the bottom of the tank, which should be blown off at least once a week to discharge any condensation that may have accumulated. If at any time there should be either oil or water in the lines, the thermostats should be removed and the oil or water blown out by opening the pin valve at the pipehead and placing the finger over the opening of the pipehead, then removing it quickly, allowing a sudden rush of air to carry the oil or water along with it. Control apparatus in large buildings maintaining an engineering staff should be placed in charge of one man. In buildings where no engineering force is maintained, the best results are assured by having a representative of the manufacturer of the particular system inspect the plant at the beginning of each heating season and make any repairs and adjustments necessary to place the plant in first-class condition.

What Is Meant by Specific Heat?

Water is with one exception supposed to be the most difficult of all substances to heat. The exception is hydrogen gas, which requires 3.40 times as much heat to raise its temperature over a given range as does water. But water is used as the standard by which other substances are compared. The increment of heat necessary to raise the temperature of water 1 deg. is called unity, or water is said to have a specific heat of 1; hydrogen, therefore, has a specific heat of 3.40. All other known bodies require less heat to raise their temperatures 1 deg. than does water, therefore their specific heat is written as a fraction, usually expressed decimally. For instance, the specific heat of steel is 0.11 or 11 per cent. of 1. The specific heat of silver is 0.055, while that of gold is only 0.03. Air is more difficult to heat, its specific heat being 0.2375; that of carbon dioxide is 0.2183, while that of methane gas, or firedamp, is 0.593.

The term specific heat, then, is the ratio of the amount of heat required to raise a given weight of any given substance (say 1 lb.) through any given temperature range (say 1 deg. F.) to the amount of heat required to raise the same weight of pure water through the same range of temperature.—*W. D. Owens, in "Coal Age."*

Manila ropes and slings and wire cables through neglect do not last as long as they should because they are allowed to decay and rust, and apart from the waste of not preserving them, they are a source of accidents. Ordinary ropes should be painted over with beeswax and resin, about equal parts of each—melted together, and applied with a paint brush. The rusting of wire cables and ropes is arrested by treating them with a mixture of tallow and oil, seven or eight pounds of melted tallow to a gallon of oil; and when the mixture is cold lime is added until it is thick. It is then applied with a brush.

Methods of Insulating A. C. Generator Coils

By H. D. STEPHENS

How armature coils are made or formed and a discussion of armature coil insulation, the characteristics and merits of the various kinds and the methods of applying them.

THE largest individual generating unit to date manufactured, represents, with its immediate auxiliaries, but without installation or building costs, an expenditure of approximately $1,500,000. An enforced shutdown of such a unit is too serious to be tolerated if at all avoidable, but in proportion to the capital invested the failure of a thousand-kilowatt unit is just as serious to its owner as that of the sixty-thousand kilowatt unit referred to. Failure of armature-coil insulation undoubtedly is responsible for more generator shutdowns than any other single cause. Insulation, therefore, should receive the attention that its importance warrants, and marked improvement has taken place within recent years in the methods of manufacturing and of insulating coils. Coils are almost invariably of the "diamond" shape, and duplicated for each machine. They may be said to have only four sides—two relatively long and straight that lie in the armature slots, and two curved sides that connect both ends of the straight sides. These curved ends are commonly referred to as end turns or end windings.

Armature coils are designated as "pulled" or "former" types, depending on the method of their manufacture. The "pulled" coil may be termed a "machine made," in that it is shaped in an adjustable "puller" machine after being wound on a shuttle to a long rectangular form with a perimeter equal to that of the finished coil. Fig. 1 shows a coil in the shuttle form, "puller" machine. "Former" coils are made over a nonadjustable wood or metal form, to the shape of the finished coil. This is a hand process requiring a separate former for each generator design, and therefore used only where "puller" coils are impossible. The use of the "former" is now very largely confined to turbo-generator coils where, on account of small number of rotor poles and therefore large coil "throw," the shape of the curved ends may be such as to prevent the use of a "puller" machine. Fig. 2 shows a wood former *A*, a turbo coil *B* with coil insulation started, and the finished coil *C*. On account of the large eddy currents in such windings, one-conductor, solid bar, coils have been superseded by coils generally having several turns or conductors in series, and each conductor is sectionalized into several parallel wires or strands. These strands are rectangular in cross-section in order to make the coil stiffer, and to utilize all the available space and to increase their safe current-carrying capacity.

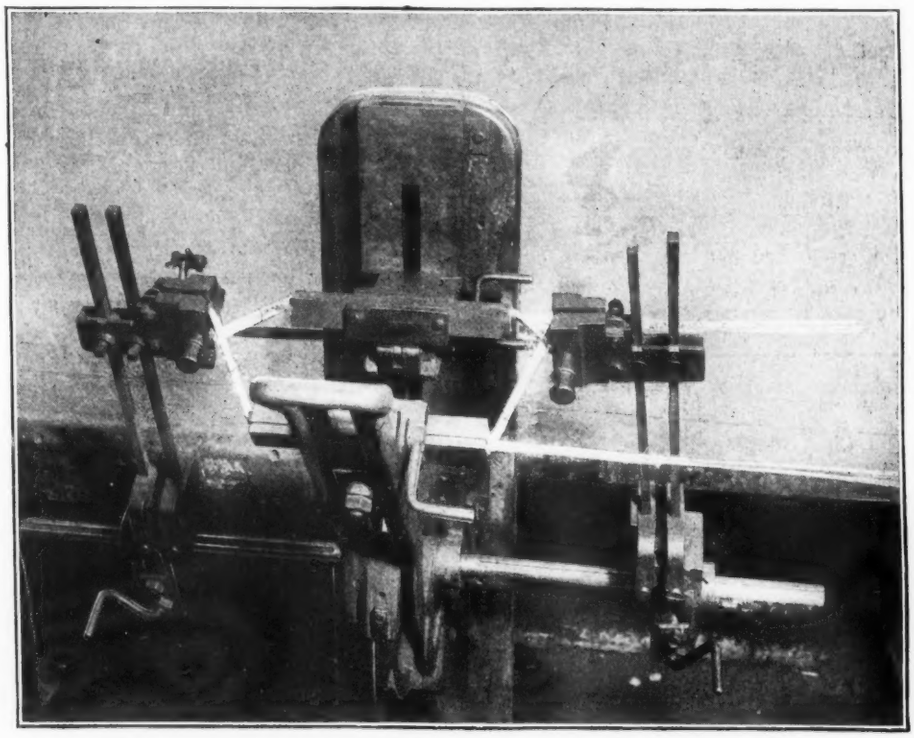


FIG. 1. SHUTTLE FORM ARMATURE COIL "PULLER" MACHINE

In discussing insulation, that which is used around individual strands or wires is known as strand insulation; that around the individual conductors of a coil as conductor insulation; and that between conductors and iron or ground as coil insulation. Two factors must be considered in deciding on the insulating materials to be employed—first and foremost, of course, the suitability of the material for the service involved, and second, the first cost of the material and the expense of application.

Special papers, treated tapes of cotton, linen and asbestos, and mica are all used at times for strand, conductor and coil insulation. Varnishes are used for impregnation—the term is applied to treating the coil under a combined heat and vacuum process to eliminate air pockets; shellacs and varnishes for sealing joints and

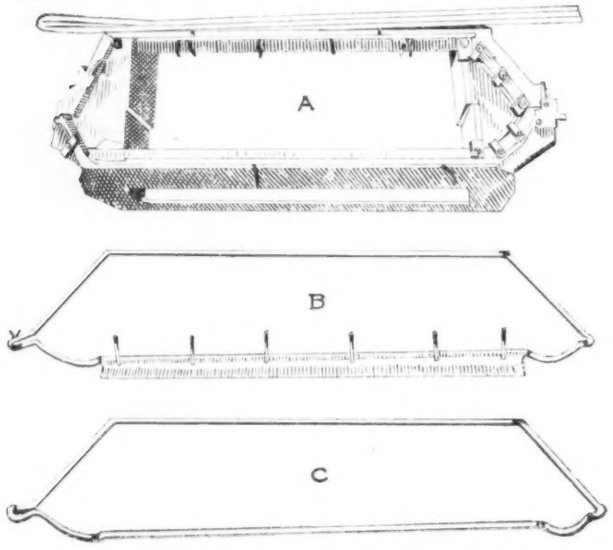


FIG. 2. WOODEN FORMER AND COILS

filling the pores of various tapes; and in some cases bakelite is used to stiffen a coil, since it bakes very hard and in addition when brushed over cotton it improves its heat-resisting qualities. Bakelite-coated cotton will safely operate at temperatures considerably

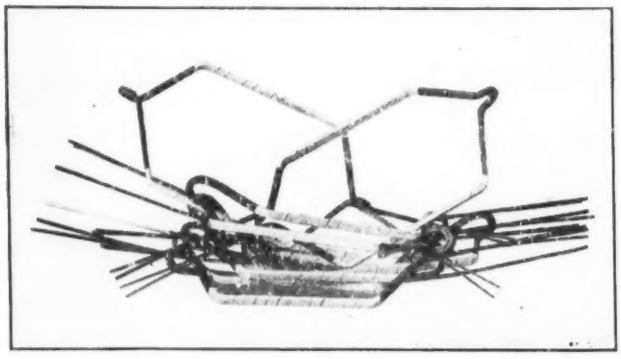


FIG. 3. COILS WITH MICA WRAPPER HELD WITH TAPE

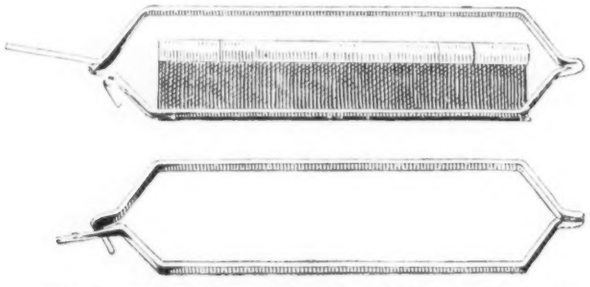


FIG. 4. COIL READY FOR INSULATION-WRAPPING MACHINE

higher than is safe with ordinary varnish-impregnated cotton.

Mica is one of the most valuable of the known insulating materials. It is a first-class dielectric, has an increasing insulation resistance with increasing temperatures, is unaffected by temperatures considerably above those present in a well-ventilated alternator, is impervious to the static discharges common to all high-voltage machines, and is sufficiently springy to be a material help in holding the coil tight in its slot. Despite the high first cost and high application cost, it is

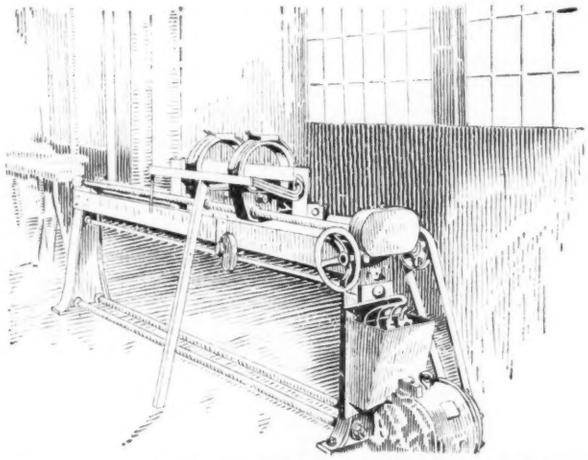


FIG. 5. MACHINE FOR WRAPPING INSULATION ON COILS

at present being used by all manufacturers of large-capacity, high-voltage and high-speed machines and appears to be almost indispensable for this service. The Westinghouse Company, for example, uses mica for coil insulation on the straight sides of all a.c. generator coils, two methods of application being employed. The mica is first backed uniformly on special paper to form a "wrapper," and this wrapper is then wound on by hand or by machine. Fig. 3 shows coils after impregnation and with the hand-applied mica wrapper held in place by tape. The end turns have not yet received the coil insulation.

The tighter and thinner the insulation wall the better

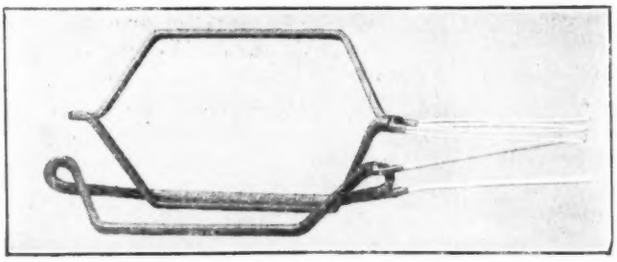


FIG. 6. ENDS OF COILS TAPED AND SHELLACKED

the heat dissipation through the insulation and the lower the operating temperature will be. For high voltage windings, 6600 or higher, the machine method of applying insulation is now generally used since this voltage demands a relatively thick insulation wall. The mica wrapper is first coated heavily with shellac on the inside, then wrapped loosely on the coil by hand, placed in the machine shown in Fig. 5 and electrically heated arms revolve around the coil. The heat softens the shellac and makes the wrapper slippery and the arms, exerting a uniform pressure, wind it down to a compact, solid wall. Fig. 4 shows the mica wrapper in place and ready for the machine, and below, a finished coil.

Strand insulation, or that around individual wires of the conductor, is ordinarily cotton. This material, properly impregnated, is good for a continuous operating

temperature of 105 deg. C. and for many machines is entirely safe on the basis of a 50-deg. temperature rise. In many wide-core, large-capacity units, however, internal "hot spot" temperatures exist, that are considerably higher than those measured by the thermometer.

For machines of this type either cotton brushed with bakelite on the strands and mica tape around conductors or mica tape on both strand and conductor is used. This mica tape is applied by hand in form of strip tape approximately one inch wide and consists of flake mica pasted on thin paper. The end windings of armature coils are finished (Fig. 6) with treated fibrous tapes carefully sealed with shellac and varnish. This part of the winding is directly in the path of the cooling air currents and is not surrounded by the iron core, therefore far easier conditions as regards both temperature and dielectric strains exist. Furthermore, the treated tapes allow a degree of flexibility that is desirable during the stator-winding operations.

After the coil is completely wound, it generally receives three tests to insure against defects in manufacture or injury during assembly. It is first individually tested for short-circuits and for dielectric strength, then it is placed in the stator and a second insulation test is applied just before the end cross-connections are made. The final test of twice the normal potential plus one thousand volts is made before dismantling the generator for shipment.

Clinkering: Its Causes and Prevention

By M. A. Saller

The matter of clinker formation is one of the most serious problems encountered in connection with the practical firing of steam boilers, especially in these days of varying quality of poor coal. This clinkering formation, or the melting and fusing of ash, not only makes it more difficult to handle and clean the fires and to keep the grates clear and in working order, but also results in a considerable money loss due to the fact that the clinker formation causes poor and unequal distribution of the air through the fuel bed, clogging up and preventing the passage of air at one point, and causing the presence of excess air at other points, thus producing spotty and inefficient burning and combustion.

Clinkering, or the massing together of the ash, is primarily produced by the melting or fusion of the ash due to the presence of excessive heat. Hence it is the result of the overheating of the ash in the fuel bed to such a degree that its melting point is reached.

It can therefore be seen that clinkering is not due entirely to the kind or grade of coal burned, but may also be due to the method of firing which will or will not permit this melting or fusing temperature to be reached. It is true that the melting point of the ash varies for different grades of coal, but it should be possible to fire any coal so that the clinkering temperature will not be reached.

Although the kind or grade of fuel may determine the extent or intensity of the clinkering action in many cases, the real causes can be attributed as follows: Carrying too thick a fire; excessive stirring or agitation of the fuel bed; presence of slack in the coal; and the presence of excessive heat in the ashpit, as caused by the presence of live coals, etc.

Probably 75 per cent. of all trouble from clinkering is due to the cause first mentioned—carrying too thick a fire. Clinkers are formed in thick fires because the depth of the fuel bed reduces the supply of air on account of the greatly increased resistance it offers to its passage. The free passage of the air up through the fire is necessary in order to cool down the ash below the live burning bed through which the air first passes, naturally tending to prevent the melting point from being reached; but as soon as the air supply is cut down, this cooling action on the ash is not secured and the temperature of the entire fuel bed increases and is liable to take on what might be termed a coking or slow-burning action with the result that the melting point of the ash is exceeded, it melts, and then cools into a solid spongy mass. It must also be considered that with a thick fuel bed the opportunity for the ash and fresh coal mixing is also increased because of the greater thickness or depth of the mixture.

A thick fire tends to increase clinkering action, and therefore where trouble is experienced along these lines, attention should first of all be paid to this particular point, for in the majority of cases it will be found that carrying a thinner fire will remove the trouble.

In considering the subject from the viewpoint of thick fires, it must also be remembered that it has been found that the presence of oxygen materially increases the melting point of ash; on the other hand, the melting point is lowered by the presence of carbon monoxide. It naturally follows, therefore, that in the thick fire, with its reduced and limited air supply, the carbon monoxide is bound to be present in excessive quantities, and the melting point of the ash is thus reduced, making it even more susceptible to the fusing or melting action.

Trouble from clinkering due to carrying thick fires can be eliminated by changing firing methods so that a thin, level fire is carried and so providing for the presence of air in proper quantities. The carrying of a thin fire means, however, that more frequent attention must be given to the firing, because the coal must be fed frequently in thin, evenly spread layers. Where, because of the heavy load conditions, it would not be practicable to carry thin fires, the desired result can be obtained by arranging for mechanical draft or blowers to furnish the increased supply and pressure of air demanded for the proper combustion of the thicker fuel bed.

Taking up the second general cause, excessive stirring or agitation of the fuel bed, we find that in stirring up the fuel bed or breaking the crust that always forms at the burning edge, chunks or pockets of ashes are almost certain to be dug up from their position under the burning bed, and these ashes are then deposited on top of the glowing fuel bed. After coming in contact with the tremendous heat of the fresh burning fuel bed, the ash naturally is melted, flows down through the bed and, on cooling, binds together everything with which it comes in contact into a solid mass or clinker. Because of this possibility of trouble, the stirring up or agitation of the fuel bed should be avoided as much as possible.

The presence of any considerable quantity of slack in the coal will also cause clinkering. The slack tends

to form a hard crust or scum over the surface of the burning coal, and when this crust is broken up and then allowed to cool, there follows the danger from clinkering along the same lines as outlined under stirring. Where excessive trouble is encountered from clinkering because of the presence of slack, the most natural course open is to look around for a grade of coal that is more suitable and satisfactory for firing purposes, but where this cannot be found it will improve conditions if the coal containing the slack is fired in small quantities, thus avoiding the collection of too great a quantity of the crust-forming slack—the cause of the trouble.

The presence of excessive heat in the ashpit will produce clinkering because this heat will tend to melt the ashes lying on the grates and then cause them to clinker. The source of heat in the ashpit is usually represented by burning coals that have been permitted to fall through the grates. To prevent any possibility of trouble from this source, a body of water should be carried in the ashpit so that any falling live coals will be promptly extinguished. If the ashpit is not water-tight, steam or hot water should be blown in after each shaking down or whenever the falling of live coal is noticed.

Summing it up, in practically every case troublesome clinkering can be avoided by carrying a thin fire; by firing coal in small, even, thinly spread charges; by avoiding stirring of the fire with slice bars and tools, and by carrying water in the ashpit to extinguish any live coals that may fall through the grates.

Efficient Boiler Operation

By J. Frank Tutein

In the past few years, designers and managers of large power plants have realized that the boiler room is the part of the plant where thousands of dollars are saved or wasted every month, and have, therefore, put forth every effort and spent large sums of money to make the working conditions desirable and to equip the boilers with instruments by which the operation may be checked every minute of the day.

There are many managers of steam plants who realize that they are not getting the proper efficiency and are consequently criticizing their operators, telling them that according to acceptance tests the plant should be doing far better work. They can see no reason why they should not be getting an average of 70 per cent. efficiency from their boilers and yet, at the end of the year, in spite of the fact that the boiler-room men have tried to burn the coal economically, the efficiency is very little, if any, better than the year before.

The manager has obtained men who are supposed to be experts; the coal has been good—his plant is in good repair—and he cannot understand why the boiler efficiency is not up to where it should be. But does he stop to think that his plant is not equipped to tell the firemen whether they are operating efficiently or not?

He has depended entirely upon the judgment of the firemen, when no man's judgment is good enough to intrust with the burning of thousands of dollars' worth of coal in a year. The main secret in burning coal efficiently is in supplying the right amount of air to the fuel bed, which of course varies with the amount of coal burned, and that in turn varies with the steam output. Therefore educate the fireman to watch the pounds of air per boiler horsepower developed, rather than the pounds of coal burned per horsepower; for in trying to cut down the coal, the fireman is likely to allow his fire to become too light, and to allow excess air in large quantities to pass through the boiler furnace.

There are several ways to check the air supply. One way is to install a meter showing the ratio between the flow of steam and the flow of air, and as long as the two lines are kept nearly together, it is safe to assume that the CO_2 is high, and the efficiency good.

Another way is to install on the boiler a steam-flow meter and a balanced-draft machine. The latter opens the back damper just enough at any load to hold a given draft over the fire. An intelligent operator will soon learn that when his fire is in proper condition and the back damper is wide open, the steam-flow meter will show the boiler to be developing its maximum horsepower; and likewise, when the boiler is developing practically no horsepower, the damper will be closed; also when the horsepower is half way between zero and maximum, the damper will be half open. In other words, with the proper amount of air supplied to the coal, the damper opening increases directly with the steam output. On the other hand, should the fire become light, or develop a hole in the fuel bed, allowing excess air to pass through, the damper will immediately open while the horsepower developed will remain low, showing the operator that for some reason he is getting too much air, and that his efficiency is dropping off.

To obtain the best results in any plant, the boilers should be equipped with some method of showing the firemen what they are doing, and any money spent in this way is well invested, provided the equipment is properly handled after being installed.

Employer's Duty to Employee

An electrical engineer was injured by an electric shock while employed in a hydro-electric power house about a generator. In suing his employer for damages, he relied upon a claim that the accident resulted from the defective condition and obsolete character of a generator that he was adjusting when shocked. Trial of the suit resulted in judgment in plaintiff's favor, but the Washington Supreme Court has reversed the judgment and dismissed the suit on the ground that the evidence was insufficient to show that the accident resulted from negligence imputable to defendant, as distinguished from carelessness of plaintiff himself, or his assumption of a known risk. The Supreme Court said, in part:

Plaintiff attributes negligence to the use of the type of generator on which he was injured, and showed that improvements have been made upon generators since 1906, by which varying loads can be better taken care of without sparking at the commutator. The generator upon which this injury occurred was of a type still in common use in electrical power plants without the latest improvements. . . . Employers are not insured, and the law recognizes that absolute safety is unattainable. They are liable for the results of their negligence and not for the dangers necessarily connected with the service. The risks incident to the employment are assumed by the person accepting such employment. An employer who uses machinery which is in common and ordinary use in the line of business in which he is engaged cannot be held liable for an accident which might have been prevented by the use of different machinery. (Griffith vs. Washington Water Power Co., 172 Pacific Reporter, 822.)

Cincinnati's New Generating Station

Big-bulk generating station with installed capacity of 50,000 kw. in two units. Steam and electrical ends arranged on unit plan. Due to wide variation in water level of river, vertical condensers are placed in deep wells under the units. Coal and ash handling extremely simple. Boilers of 1262 hp. equipped with underfeed stokers and natural-gas burners in the rear wall

SINCE 1898 the Plum Street generating station has been practically the only source of power from which the Union Gas and Electric Co., of Cincinnati, supplied its customers. It is located over a mile from the Ohio River, where coal delivery is expensive and water from the Miami Canal for condenser cooling is uncertain. The canal is to be abandoned and filled up, which will reduce the water supply, and notwithstanding many additions and changes, continually increasing demands have made a new and larger plant necessary. Reference to Fig. 3, showing the load curves of the company for the past few years and the expectations for the immediate future, will tell the story. The old plant will be retained as an emergency station.

The new plant had to be located on the river and as the company had such property within a mile of the main business section of the city, it was located on this site. Fig. 2 is a plat of the property showing roughly the layout of West End station, as it is called, for four units, the coal-storage yard and the tracks entering the property. The building has been built for four units, two of 25,000-kw. capacity having been installed. Two more of the same rating are to be installed in the near future, and there is plenty of room on the site for extension of the building eastward to house four more units. The plant is to be a big-bulk generating station distributing in quantity to substations and not to the customer direct.

For substantial construction, simplicity of design and ease of operation the plant has no superior in this country. Both the steam and the electrical ends are arranged on the unit plan. Four boilers of 1262 hp. each serve a turbine. The operating pressure is 250 lb. gage and the superheat 250 deg., so that the steam temperature in the boilers will approximate 650 deg. F., which approaches the practical limit for equipment of current design.

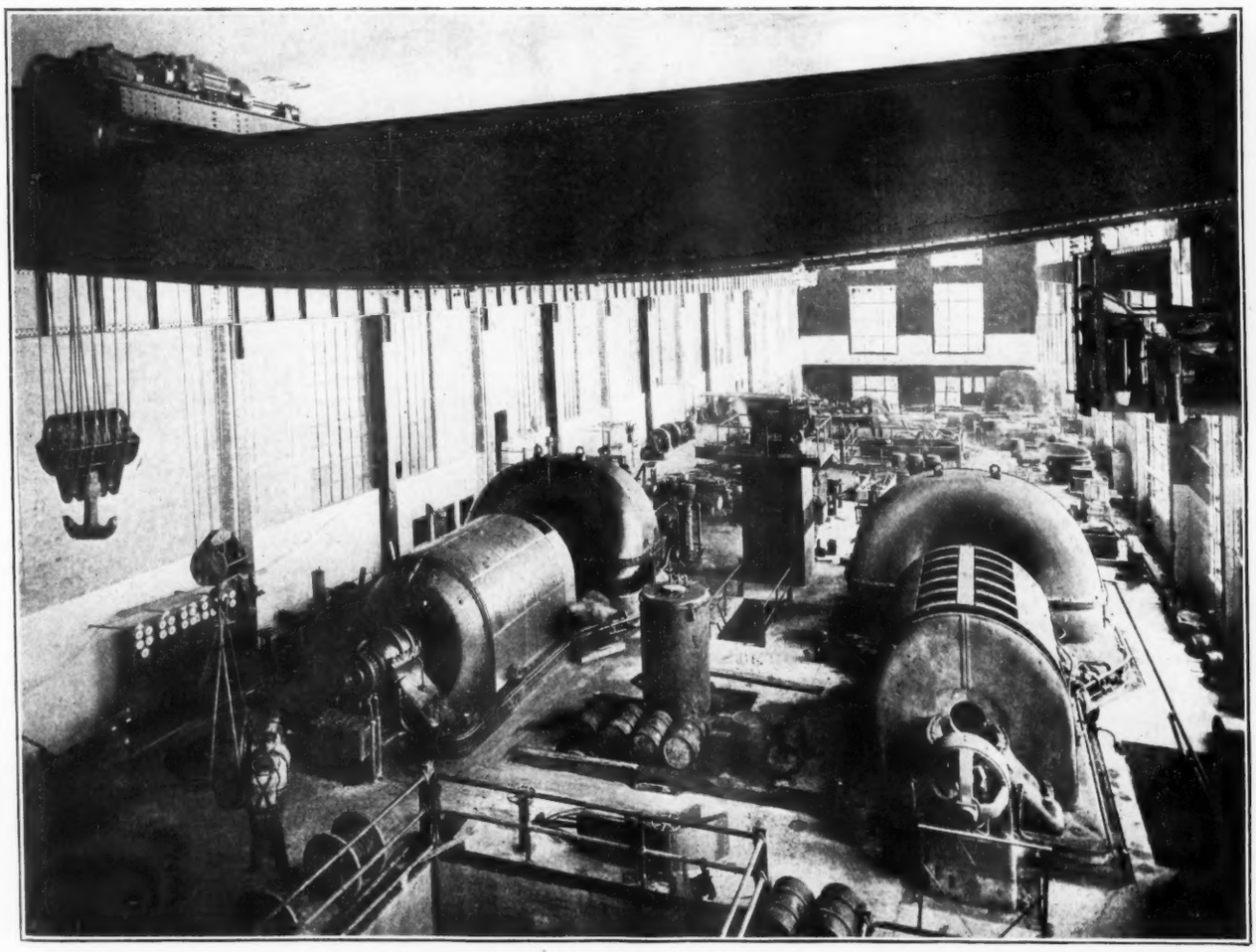


FIG. 1. VIEW OF TURBINE ROOM DURING ERECTION

Conditions existing at the site chosen for the plant imposed difficulties of an unusual character. Due to spring floods in the valley above Cincinnati, the river fluctuates in level about 70 ft. At the extreme high-

water mark the tract on which the plant rests has been flooded with 6 to 8 ft. of water. The ground consists of a fill of cinders, slag, etc., about 50 ft. deep, resting on native sand and gravel. As foundation work would be expensive, the area covered by the station was limited. Large units were employed and by the use of heavy steelwork the switchhouse was placed over the turbine room.

Due to the excessive lift of condensing water that would be required at all times except during the flood

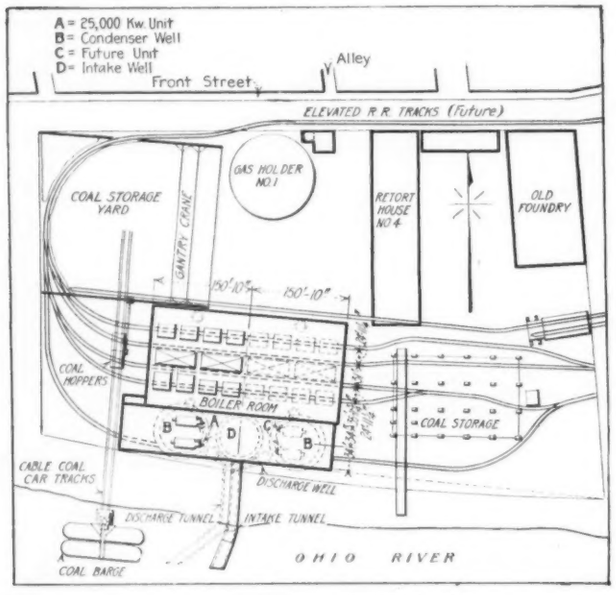


FIG. 2. PLAT OF PROPERTY ON WHICH PLANT IS BUILT

stage of the river, the conventional arrangement of condensing equipment was not feasible. Under the turbines condenser wells 86 ft. deep and 60 ft. diameter were sunk, and at the bottom were placed vertical condensers and the auxiliary pumps. Other features of the station are simple coal and ash handling and natural-gas burners in the rear walls of the boilers to be used independently when there is a surplus of gas or in conjunction with coal on underfeed stokers at the front of the settings. The building has been made high enough to admit coal and ash cars at grade, eliminating ash-conveying equipment, and by the use of automatic side-dump cars delivering to a pit within the station, reducing the coal-handling equipment to two traveling cranes, each with a grab bucket that is emptied directly into large extension hoppers for each stoker.

Reference to Fig. 4 and the accompanying insert will show the general arrangement of the station. It will be noticed that the boilers are placed on each side of a central aisle. The opposing pairs form a unit. The boilers are of the cross-drum type, each containing 12,625 sq.ft. of steam-making surface and a superheater that will raise the temperature of the steam 250 deg. above that corresponding to the pressure. The boilers are equipped with 14 retort underfeed stokers and at the rear are 72 gas burners arranged in three rows of 24 each. In practice the natural gas at 8 oz. pressure will be burned when there is a surplus, and at times it is also planned to burn both gas and coal.

On leaving a boiler the gases of combustion pass directly upward in a flue passing between a double economizer serving the boiler. Through openings on either side the gases may pass through the economizers to an induced-draft fan and thence to the stack, or the economizers may be bypassed and the gases enter the flue directly. Each pair of economizers contain 576 4-in. 12-ft. tubes having an aggregate surface of 8256 sq.ft., or about two-thirds of the steam-making surface in the boiler. The economizers are of the high-pressure counter-flow type and will probably operate under a maximum pressure of 325 lb. The induced-draft fan has a capacity of 90,000 cu.ft. per minute. It is driven at 360 r.p.m. by a 75-hp. alternating-current motor and is expected to produce a draft at the boiler uptake of 1½ in. One steel stack, firebrick lined, has been provided for each row of four boilers installed. The diameter at the top is 15 ft. and the height 175 ft. above the boiler-room floor.

Back of each boiler at the operating-floor level is its forced-draft fan having a capacity of 50,000 cu.ft. per minute, driven by a 100-hp. induction motor. The

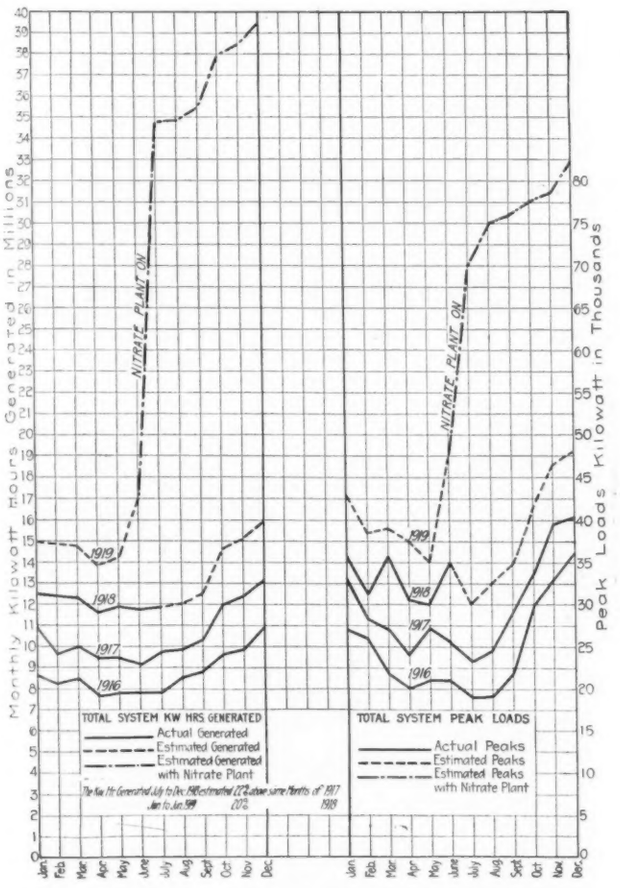


FIG. 3. RAPIDLY INCREASING LOAD SECURED BY THE COMPANY

motors driving the economizer and stoker fans are 550-volt alternating-current machines. The stokers, however, are driven by individual 35-hp. variable-speed direct-current motors mounted in front on the boiler-room floor. Through a chain drive to a lineshaft and chains from the shaft to the individual retorts each motor operates its stoker. The motors are large enough, however, to drive two stokers and a connecting shaft can be inserted in case of trouble with one of the motors, for driving the stoker on the adjacent boiler.

For the coal and the air there is no automatic control. The speeds of the stoker motor and of the motor driving the forced-draft fan are hand regulated by street-car controllers mounted at the side of the stoker and near the aisle between adjoining boilers. Across the aisle at sufficient height to give head room is the instrument panel for the two boilers. On top are steam-flow meters, two per boiler, as the steam is drawn off on either side. On the panel are three recording thermometers for each boiler, all being double-pen instruments. One records the temperatures in both steam lines from the boiler; another gives the feed-water temperature at the boiler and the temperature at the entrance to the economizer. The third instrument gives the gas temperature at the boiler uptake and at the economizer outlet. There are also a pressure gage for each boiler, and a three-in-one draft gage giving the pressure over the fire, at the boiler uptake and at the economizer outlet. When the panel is complete it will contain U-tubes indicating the draft in the wind boxes of the stokers and a recording watt-meter to show the load on the turbo-generator served by the boilers.

All high-pressure piping is extra heavy and steel fittings are employed. The 7-in. leads from each side of two boilers combine through a special fitting at the rear into a 14-in. pipe that crosses the central aisle under the boiler-room floor and combines with a similar pipe from the opposing pair of boilers completing the unit. The supply pipe to the turbine has a diameter of 17 in. Cross-connection from one unit to the other makes it possible for either set of boilers to feed either turbine.

Feed water for the boilers is mostly condensate, which is delivered from the hotwell through a preheater in the condenser to the feed-water heater. There is one heater for each unit of four boilers. It is of the open cylindrical steel-shell type having capacity to heat 330,000 lb. of water per hour from 60 to 130 deg. F. Make-up water comes from a hot-water reservoir in the basement. It receives all clean drips from the station and the supply is augmented when necessary by filtered water from the river. The river water is forced through duplicate pressure filters that may operate singly or in parallel. For normal operation one filter has sufficient capacity, and the other may be used as an alternate at times of cleaning. The filtered water goes to a header having connection with the reservoir. It also has connection to the unfiltered-water header supplied directly from the river, so that in case of necessity plain river water may flow to the reservoir. From the latter makeup is pumped to the heater under float control and arrangements are made for any overflow from the heater to return to the reservoir.

For the two units there are four feed pumps, three being turbine-driven and one motor-driven. They receive their supply under head from the heaters, and force the water through the economizers to the boilers or through an auxiliary line directly to the boilers. The pumps are cross-connected so that they are interchangeable and the feed is regulated by hand.

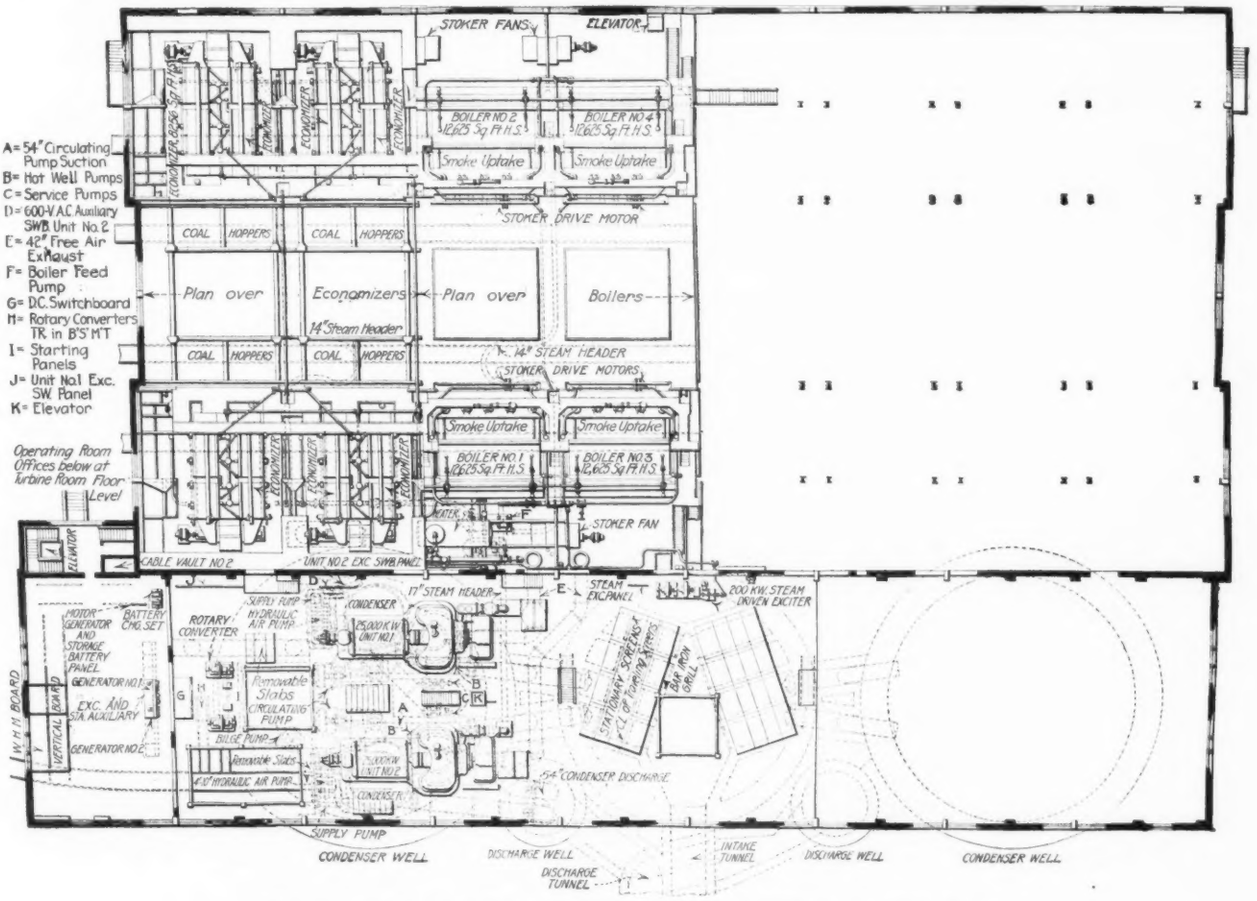


FIG. 4. PLAN OF PRESENT BUILDING LAID OUT FOR FOUR UNITS

Coal will be received mostly by rail over four connections into the property from the various railroads entering Cincinnati. It may enter the main storage yard north of the plant or a smaller yard on the east side of the property, the latter having been used formerly by the gas plant; or it may enter the boiler room directly, as a coal track has been provided for each row of boilers. Within the plant there is a storage pit under the two tracks of 7000 tons capacity. If of the proper size the coal may be dumped directly into the pit or, if not, be transferred to a traveling crusher placed below and between the two tracks. From the pit the coal is raised by traveling cranes provided with a 3-cu.yd. car that delivers directly to individual extension hoppers for the stokers. Scales on the crane permit weighing while the coal is being put into the stoker hoppers. Each stoker hopper has a capacity approximating 100 tons, so that it will hold sufficient coal for a run of 16 hours at high rating.

The north yard is served by a gantry crane with a span of 140 ft., and under the gantry there is room to store 70,000 tons. In the east yard there is space for 30,000 tons, so that there may be a total storage of 100,000 tons. Coal enters the north yard on a track provided with a dumping pit outside the gantry span. The crane is provided with a folding arm that may be raised or lowered by motors to avoid a gas tank on the property. The hinged cantilever, which is 35 ft. long, extends over the dumping pit so that the coal may be picked up, transferred to the main span of the gantry, and dumped in any part of the yard. Its capacity is about 200 tons per hour.

When coal is transferred from storage to the power plant, it is picked up by one of the buckets serving the crane and loaded through a four-roll crusher on the gantry leg into one of the special side-dump cars owned by the company. By a steam locomotive of the Porter fireless storage type, also part of the equipment of the company, the car is pulled into the boiler room and unloaded as previously described.

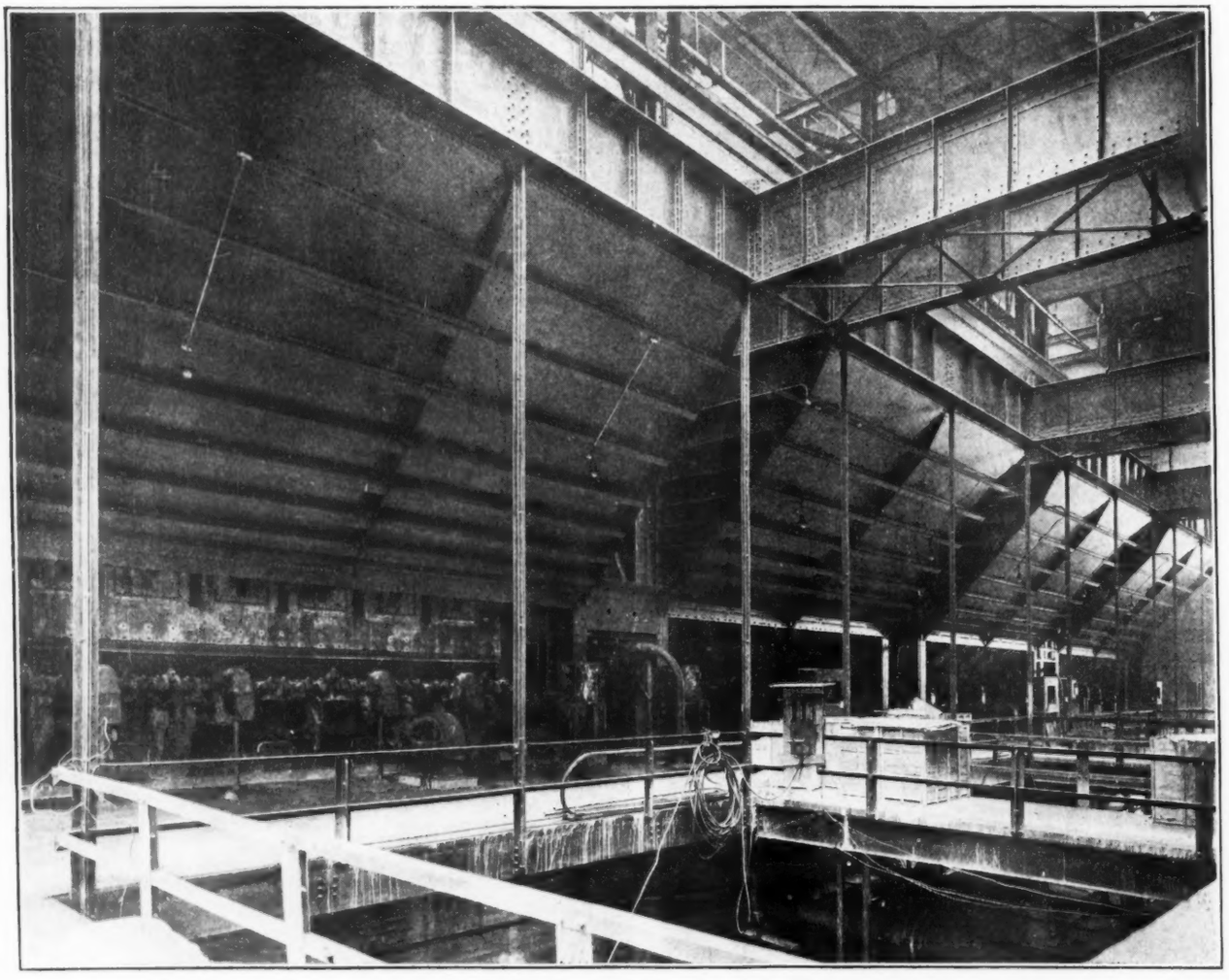


FIG. 5. BOILER FRONTS ON ONE SIDE OF THE CENTRAL AISLE

In the east yard there is provision for unloading coal from barges on the river. It is a skip-hoist equipment having two tracks and two cars dumping at the top of the incline to the storage below. This equipment is to be replaced by a more pretentious conveyor at the west end of the plant. It will probably consist of a hoisting tower provided with a grab bucket that will transfer the coal from the barge to a crusher on the tower, the latter delivering to a bucket conveyor discharging into the coal cars previously mentioned. An ash track for each row of boilers is also provided, and the ashes are dumped directly into the cars.

In the turbine room the condensing equipment and the arrangement of the electrical installation present interesting and unusual features. Fig. 1 shows that the installation of two units is nearing completion. At the opposite end of the station duplicate units will be installed at a later date. Liberal space has been provided around the units and there is a noticeable absence of auxiliary machinery on the turbine-room floor, the

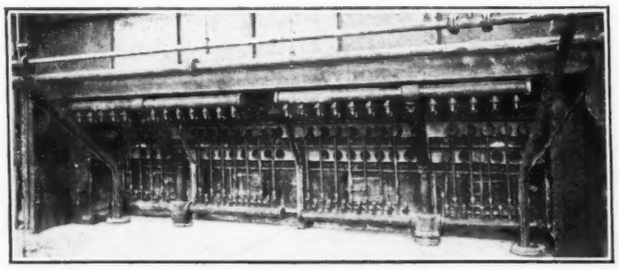


FIG. 6. NATURAL-GAS BURNERS INSTALLED IN REAR WALL OF SETTING

only machinery in addition to the main turbo-generators being a double-generator turbine set to deliver direct current for excitation and for direct-current station auxiliaries, and two 750-kw. synchronous converters. The main units are rated at 31,250 kv.-a. or 25,000 kw. at 80 per cent. power factor. The turbines are 17-stage machines having a speed of 1800 r.p.m. The generators deliver three-phase 60-cycle current at 13,200 volts. Each has a 250-volt 140-kw. direct-connected exciter that has sufficient capacity for the two machines. For the same purpose there is the independent double-generator turbine set previously mentioned. Through

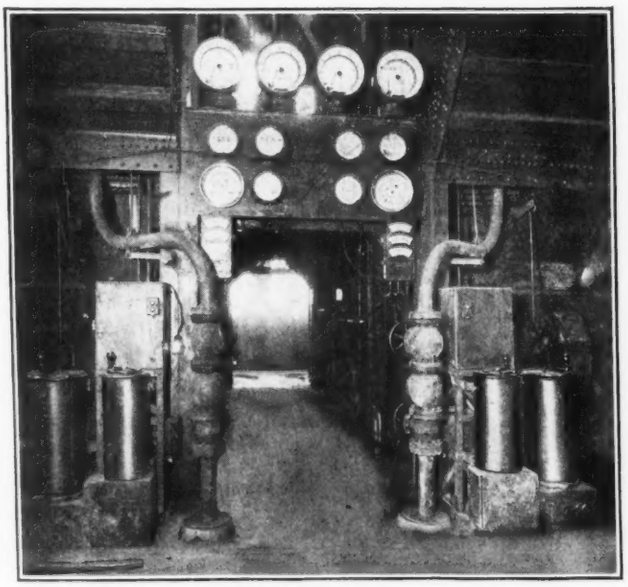


FIG. 7. INSTRUMENT PANEL BETWEEN ADJACENT BOILERS

reduction gearing the turbine speed of 3600 r.p.m. is reduced to 1200 r.p.m. for the generators. Each machine is rated at 200 kw., one delivering current at 250 volts for excitation and the other supplying 600-volt direct current for the stoker and crane motors. Excitation current may be taken also from a storage battery large enough to supply the eight units that the station may eventually contain. The battery will be used for only a short period, at such times as it is necessary to change over from the direct-connected exciters to the independent steam unit.

To provide for the condensing equipment and cooling water, five wells were sunk below the turbine room, as shown in the plan view, Fig. 4. The center one is the intake well; on each side is a condenser well for two

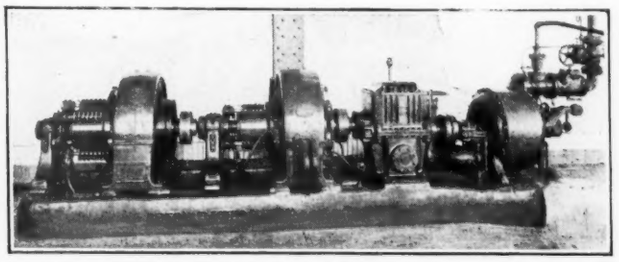


FIG. 8. DIRECT-CURRENT DOUBLE-GENERATOR TURBINE DRIVEN UNIT

units and between each condenser well and the intake well is a discharge well. Tunnels from the river run into the intake well and from the discharge wells back to the river, downstream from the intake.

Each condenser well is 68 ft. in diameter inside and 84 ft. deep from the basement floor. The condensing equipment for the first two units is located at the bottom of the west well, the other well being provided for the third and fourth units to be installed later. From the basement floor the intake well is 86 ft. deep and 60 ft. in diameter inside. The bottom is approximately 16 ft. lower than the stream's low-water mark, so that there should always be a plentiful supply of water under all river conditions. The well contains a

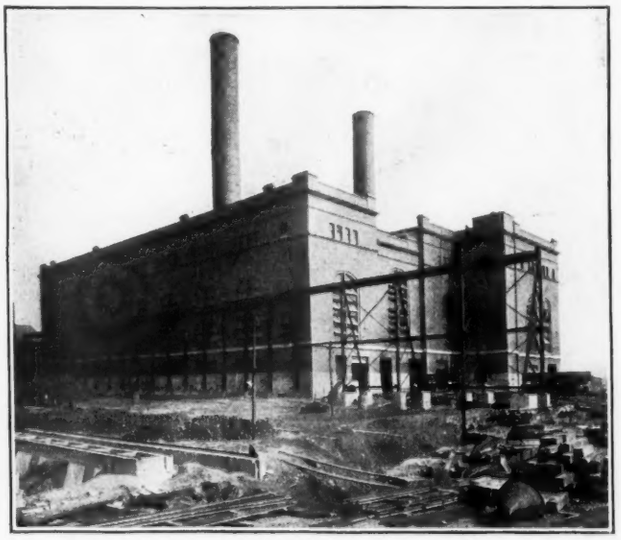


FIG. 9. LOOKING AT THE NEW POWER PLANT TOWARD THE RIVER

heavy bar-iron grill to remove the coarser débris floating in the river, and behind the grill are traveling screens to remove any rubbish that passes through the grill. A set of stationary screens is also provided to supplement the traveling screens when necessary. The intake tunnel leading into the bottom of the well is 163 ft. long, 10 ft. wide, and 25 ft. high, with reinforced-

concrete walls 3 ft. 6 in. thick. From the intake tunnel the cooling water passes through the screens into 54-in. suction pipes extending through the floor of the condenser well to the circulating pumps. From the condensers the cooling water is discharged through 54-in. pipes to the discharge wells and from there back into the river through the discharge tunnels. The entire cooling-water system from the intake well to the exit of the discharge tunnel into the river is a closed siphon, so that it is only necessary for the circulating pumps to overcome the friction in the piping and the condensers.

The discharge wells are 17 ft. in diameter inside with walls 3 ft. thick. As in the case of the condenser wells only the west discharge well is used for the first installation. The two discharge pipes from the condenser well enter the discharge well at the level of the top of the condenser, and drop to the bottom of the well, where they are sealed into the end of the west branch of the discharge tunnel. Two 6 x 10-ft. tunnels, one from each discharge well, meet on the river side of the station and form a single discharge tunnel, 10 x 10 ft., which extends 214 ft. in a downstream direction from the intersection. More complete details of the construction of these wells and tunnels are given in an article appearing in the Jan. 29, 1918, issue of *Power*.

Each condenser is of the vertical two-pass type containing 52,000 sq.ft. of surface in 1-in. tubes 18 ft. long. The guaranteed capacity is 330,000 lb. of steam per hour. Exhaust steam from each turbine passes through a vertical exhaust pipe 13 ft. in diameter and 62 ft. long to the condenser on the floor of the well. Steam enters the condenser through an opening extending practically the full height between the two tube plates. Condensation from the turbine and the exhaust pipe collects in the hotwell at the bottom of the latter, and does not enter the condenser. From the condenser the condensation also drains to this hotwell. It is passed through preheating tubes set off in the condenser to the feed-water heater, as previously described.

Circulating water enters at the top of the condenser and leaves at the same level on the opposite side. The pump is a 42-in. centrifugal having a capacity of 56,000 gal. per minute. It is driven by a 640-hp. induction motor at 350 r.p.m. Two condensate pumps are provided per unit, one being a spare to insure continuity of service. They are two-stage 6-in. centrifugal pumps, each having a capacity of 1200 gal. per minute, driven by a 153-hp. induction motor at 1800 r.p.m. Air from each condenser is removed by four 10-in. hydraulic nozzles. The necessary water is supplied by two motor-driven 10-in. centrifugal pumps connected in a closed circuit. The nozzles discharge into a tank cooler, provided with cooling coils, in which the air is liberated and the water is again taken by the pumps and forced through the nozzles. To keep this supply of nozzle water cool, water is taken from the discharge of the main circulating pump, passes through the tubes of the cooler, and is discharged into the lower water box of the large vertical condenser at the beginning of the second pass. At the center of the well is an elevator giving ready access from the turbine-room floor.

As in the steam plant, the electrical end of the station has been arranged on the unit plan. A ring bus

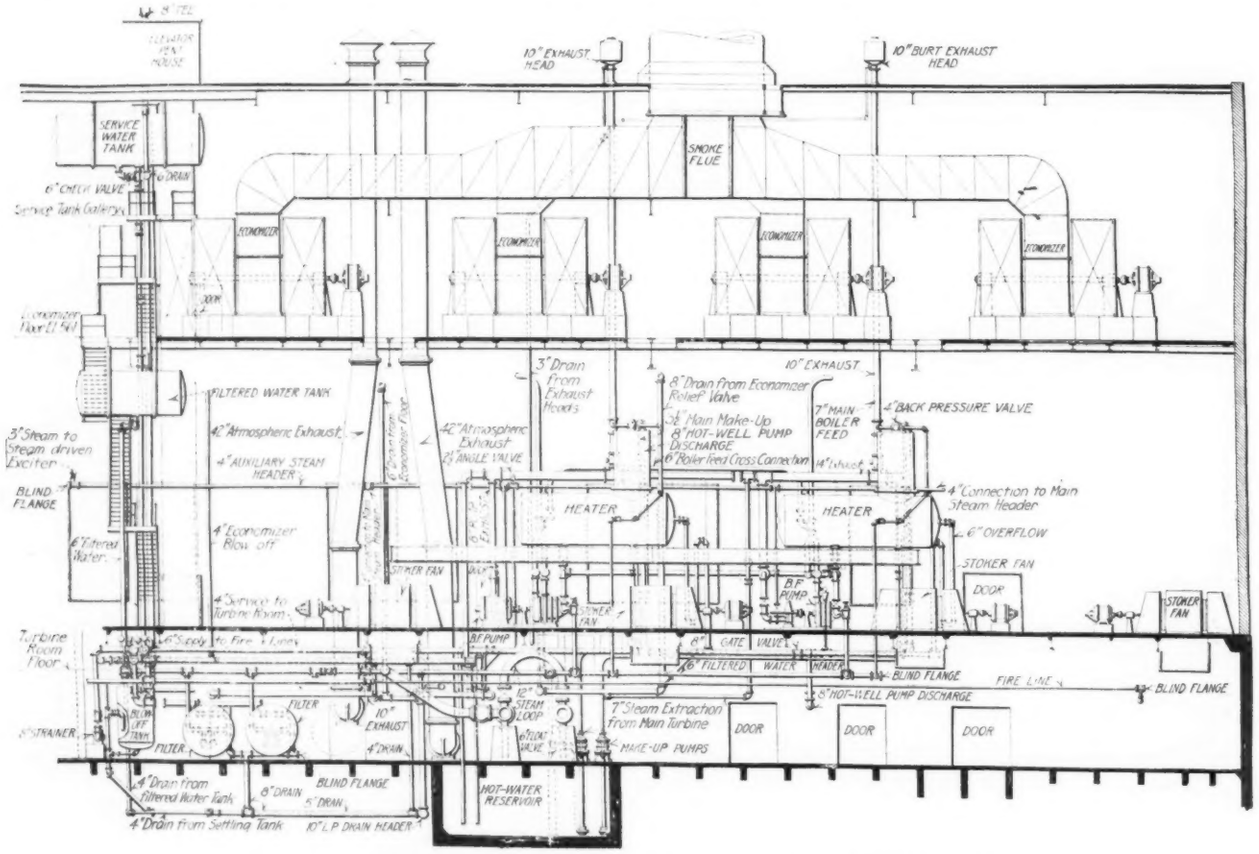


FIG. 10. LONGITUDINAL SECTION OF BOILER ROOM LOOKING SOUTH

system is employed. The diagram, Fig. 11, drawn up for eight units, shows simply the general scheme. Each generator supplies its particular section of the bus and the corresponding feeders. Between each unit is a 5 per cent. bus reactance with a short-circuiting switch

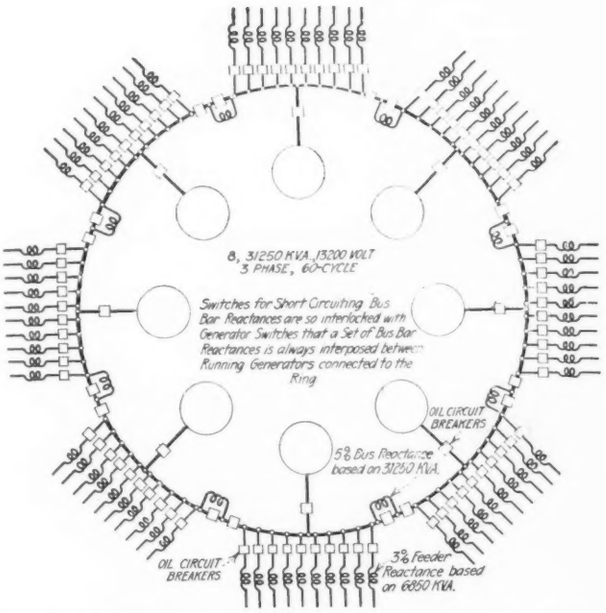

8, 31250 KVA, 13200 VOLT 3 PHASE, 60-CYCLE
Switches for Short Circuiting Bus Bar Reactances are so interlocked with Generator Switches that a Set of Bus Bar Reactances is always interposed between Running Generators connected to the Ring
OIL CIRCUIT BREAKERS
5% Bus Reactance based on 31250 KVA.
OIL CIRCUIT BREAKERS
3% Feeder Reactance based on 6850 KVA.

FIG. 11. DIAGRAMMATIC SCHEME OF RING BUS SYSTEM DRAWN FOR EIGHT UNITS

so interlocked with the generator switch that it will close when the latter opens, and cut out the reactance. Due to this provision only one reactance can intervene between running generators, and the voltage troubles that might ensue if the current from one section of the bus should pass through several reactances in series are eliminated. In each feeder circuit is a 3 per cent. reactance based on 6850 kv.-a. As each unit is added the busses are simply tied across, so that the ring effect is maintained at small expense in bus structure or copper.

Fig. 12 is a single-line diagram showing in a simple manner the electrical connections. Current from each main unit is fed at the generator voltage of 13,200 volts, either into its respective main bus or the reserve bus. As indicated in the previous illustration each machine has its individual section of the bus, each section being connected through a sectionalizing switch of the oil circuit-breaker type and the bus reactance. Each division of the main bus has a definite number of feeders and in addition supplies through an 1800-kv.-a. transformer a 600-volt alternating-current bus for the station motors belonging to the particular unit in question. The connection continues to an emergency bus, so that when necessary the 600-volt alternating-current busses may be fed from any unit in the station. There is also an additional 600-volt alternating-current bus for supplying the lighting, step-down transformers

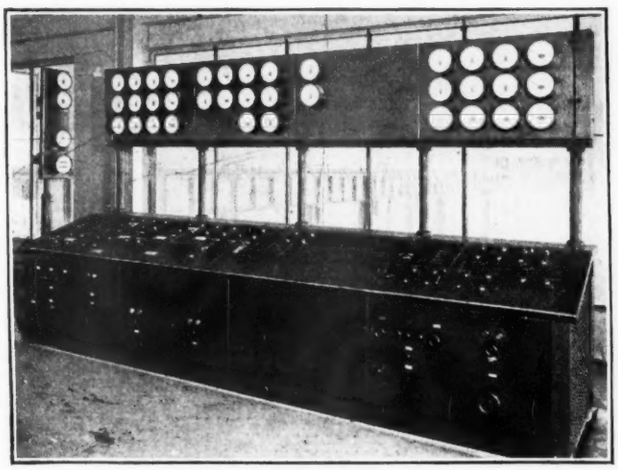


FIG. 13. BENCHBOARD PARTLY COMPLETE, FROM WHICH ALL GENERATOR 13,200-VOLT CURRENT IS CONTROLLED

and connections to the synchronous converters supplying the 600-volt direct-current bus for the stoker and crane motors. The 600-volt machine of the double-generator unit is also connected to this bus. At the bottom of the diagram the three sources of excitation current are indicated.

Generator and sectionalizing circuit-breakers are nonautomatic. The feeder switches have definite time-limit overload relays. All are of the triple-pole, single-throw, solenoid-operated oil circuit-breaker type.

Immediately above the turbine room is the conduit distribution room, on the floor of which all cables are arranged in a systematic order giving ready access and maximum protection. The outgoing cables are brought down the turbine-room wall in runways to vaults below grade and carried out in underground ducts arranged five deep and two wide. This design provides the maximum radiating surface and at the manholes simplifies

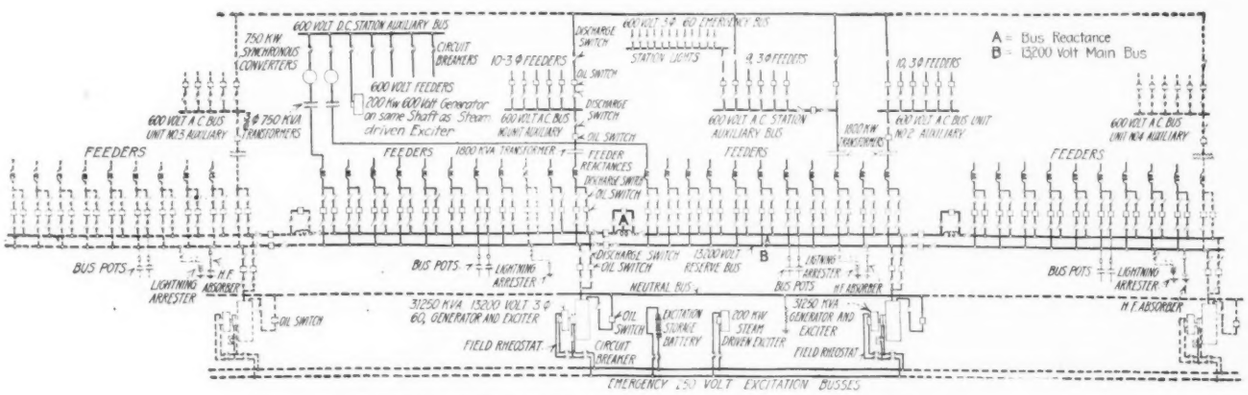


FIG. 12. SINGLE-LINE DIAGRAM OF ELECTRICAL CONNECTIONS

the cable arrangement. Around the ducts is a heavy bed of concrete made waterproof. Manhole covers below high water are made water-tight. From the station, transmission is over 400,000-c.m., three-conductor cables $\frac{7}{32}$ x $\frac{7}{32}$-in. paper insulated with $\frac{9}{64}$-in. lead over all.

PRINCIPAL EQUIPMENT OF WEST END STATION, CINCINNATI

Boilers	
Type of boiler, Babcock & Wilcox cross-drum water-tube	
Number now installed	8
Steam-making surface, sq.ft.	12,625
Working pressure, lb. gage	250
Superheat, deg. F.	250
Temperature of steam, deg. F.	656
Capacity of each boiler, lb. steam per hr.	100,000
Stokers	
Westinghouse underfeed, 14 retorts per boiler	
Capacity, lb. coal per hr.	13,000
Driven by D.C. motor (two stokers), hp.	35
Economizers	
Sturtevant high-pressure, max. op. press., lb. per sq.in.	325
Heating surface per boiler, sq.ft.	8,256
Pumps	
Four boiler feed, Worthington, 3-stage 6-in. centrifugal	
Capacity, g.p.m.	750
Three turbine-driven, one driven by 300-hp. ind. motor	
Two service pumps, Worthington, 2-stage 6-in. centrifugal	
Capacity, g.p.m.	800
Driven by 100-hp. ind. motor, 1800 r.p.m.	
Two make-up water pumps	
Pressure filters, two International	
Feed-water heaters, one per unit	
Platt open cylindrical, shell type	
Capacity, lb. per hr., from 60 to 130 deg. F.	330,000
Fans	
Forced-draft, one per boiler	
Buffalo turbo-coroidal, cap., cu.ft. per min.	50,000
Driven by 100-hp. ind. motor, speed, r.p.m.	1,175
Induced draft, Sturtevant multivane, one per boiler	
Capacity, cu.ft. per min. at 300 deg. temp.	90,000
Driven by 75-hp. ind. motor, speed, r.p.m.	360
Stack, steel, firebrick lined	
Height above boiler-room floor, ft.	175
Diameter at top, ft.	15
Boilers per stack	4
Coal Storage	
Extension hopper on each stoker, tons	100
Pit under central aisle, tons	7,000
Yard storage, tons	100,000
Cranes	
Boiler room, Whiting, traveling type, 3-cu.yd. bucket	
Span, ft., in.	48-3
North storage yard, Whiting gantry, 3- and 5-cu.yd. buckets	
Span, ft.	140
Coal Crushers	
Boiler room; traveling 4-roll, Orton & Steinbrenner	
Capacity per hour, tons	150
On Gantry in storage yd., 4-roll, Orton & Steinbrenner	
Capacity per hour, tons	150
Turbines	
Two 25,000-kw. at 80 per cent. power factor	
G. E. single-cylinder, horizontal, 17-stage	
Speed, r.p.m.	1,800
Operating pressure at throttle, lb. gage	230
Superheat, deg. F.	250
Net weight of unit, lb.	652,000
Weight per kw. of rating, lb.	26
Floor space, outside measurements, sq.ft.	960
Floor space per kw., sq.ft.	0.0384
Generator	
Two G. E. three-phase, 60-cycle, 13,200-volts	
Air for cooling, cu.ft. per min.	60,000
Air washer, one per unit, Spray Engineering Co.	
Exciters	
One direct-connected to each unit, kw.	140
Voltage	250
Speed, r.p.m.	1,800
One G. E. independent steam exciter, turbine-driven, reduc. gears	
Part of double-generator unit, capacity of each gen., kw.	200
Voltage	250 and 600
Synchronous Converters	
Two Westinghouse, 600-volt D.C. plant service, kw.	750
Condensers	
Two Worthington, vertical surface, two-pass	
Tubes, 1 in. in diam., 18 ft. long	
Surface, sq.ft.	52,000
Capacity each cond., lb. steam per hr.	330 000
Four traveling screens for two units. Link Belt	
Circulating pump, Worthington, volute	
Capacity, g.p.m.	56,000
Pump capacity per lb. steam cond., lb.	85
Driven by ind. motor, hp.	640
Speed, r.p.m.	350
Condensate pumps, two per unit, Worthington two-stage	
Capacity, g.p.m.	1,200
Driven by 153-hp. ind. motor, speed, r.p.m.	1,800
Air pumps, Worthington hydraulic nozzles	
Number per unit	4
Pumps supplying water to nozzles, 2 Worthington 10-in.	
Capacity each, g.p.m.	3,200
Driven by 185-hp. ind. motors, speed, r.p.m.	1,800
Crane, turbine room, Whiting 110-ton	
Span, ft. in.	66-10
Equipped with 15-ton auxiliary hoist	
Switchboard throughout, Westinghouse	

Above the conduit floor is located the switchroom supported by the heavy steelwork, and here are the bus structures and the oil switches, a reserve and main bus being located on each side of the room as indicated. All high-voltage switching is done in individual cells, bus bars and oil switches being isolated in brick and concrete compartments.

At one end of the station overlooking the entire turbine floor is the operating room. Fig. 13 shows the benchboard, from which all 13,200-volt generator current is controlled. On panels above the bench are the generator, synchronous converter and reserve exciter instruments and on a pedestal at the left are the voltmeters, frequency and synchronous indicators. On

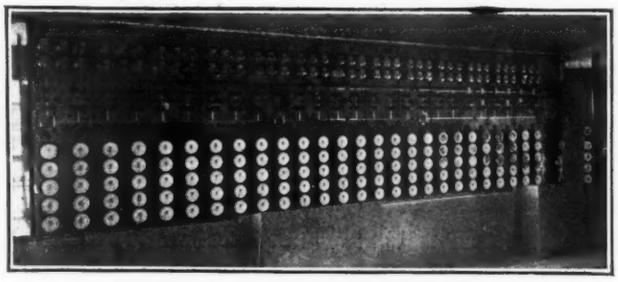
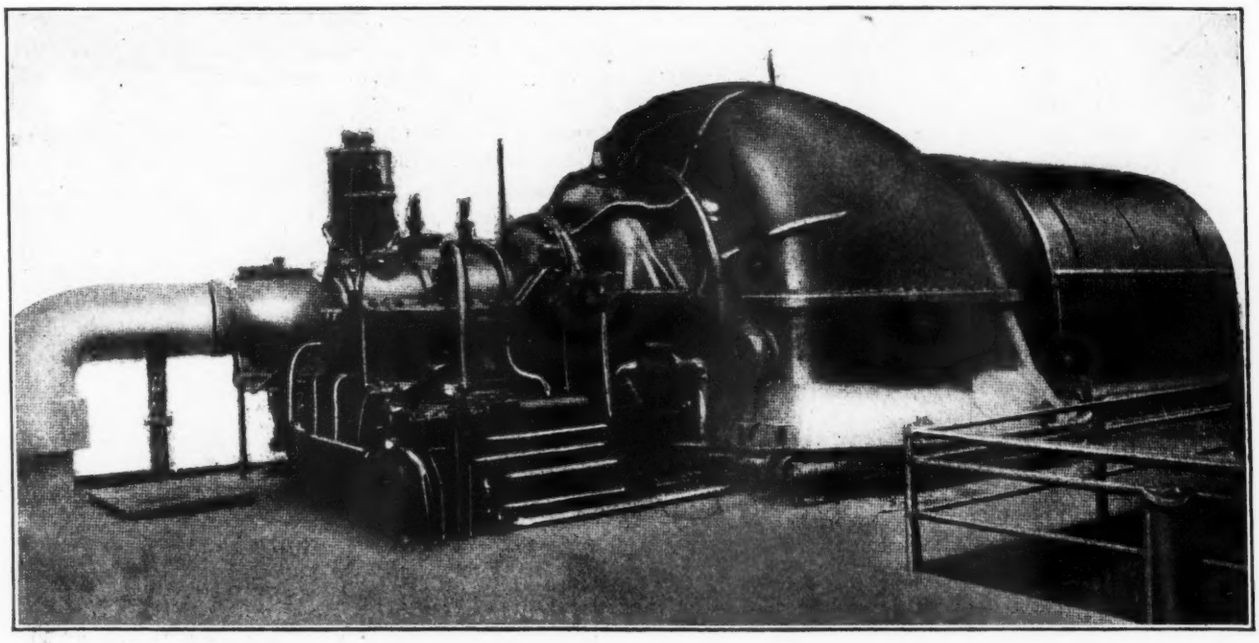


FIG. 14. INSTRUMENT BOARD FOR FEEDER CIRCUITS, WATT-HOUR METER BOARD IMMEDIATELY BEHIND

the opposite side of the room is a vertical switchboard, shown in Fig. 14, containing the feeder instruments and control switches, the relays and the testing terminals. There is a pedestal at the left with instruments duplicating those on the benchboard pedestal. Directly back of this board is another containing the watt-hour meters. On the turbine-room floor are the 600-volt unit auxiliary switchboards. On all there is a complete equipment of the latest instruments, control and signaling devices.

Sargent & Lundy, consulting engineers of Chicago, are responsible for the design and installation of the station. W. W. Freeman is president of the Union Gas and Electric Co., and C. W. DeForest is manager of the electrical department. C. R. McKay represented the Union Gas and Electric Co. on all work in connection with this station. Mr. McKay was unfortunately killed in an automobile accident on May 14.

A new turbine is being installed at the power plant of the West Virginia Traction and Electric Co., Morgantown, W. Va., and it will be in operation shortly. The company has been endeavoring to get this added unit installed for some time, but has been delayed, and in the meantime, it has required the full capacity of the plant to maintain the supply of current needed for various uses in the city. Manager J. K. Buchanan states that within thirty days the local company will have a connection with the Fairmont company, thus making available a new supply of electric light and power.



A 35,000-kw. Turbine Is Wrecked in Northwest Station, Chicago

Detailed description of the accident to the 35,000-kw. turbine at Northwest Station, Chicago, Ill. Failure of the nineteenth wheel is the probable cause of the wreck.

On Wednesday, Aug. 1, a 35,000-kw. 20-stage, 1500 r.p.m., 25-cycle, horizontal, single-cylinder impulse turbine in the Northwest Station of the Commonwealth Edison Co., Chicago, Ill., was completely wrecked. The main generator and possibly some of the wheels are the only parts not seriously damaged. There were no fatalities and no casualties. A piece of flying metal went through the clock, stopping it at 12.17 a.m. The turbine had been in service since December, 1917, and is of the latest design of the General Electric Co. It is shown in the headpiece.

Naturally, one of the first thoughts of engineers on learning that the machine was wrecked was: Is this accident a parallel with the accident to the turbine of the same type and capacity wrecked in the O Street Station of the Elevated Railways Co., Boston, Mass., Feb. 14, of this year? It is not identical, though the trouble was in the low-pressure end, as at Boston. The apparent initial cause of the accident to the Boston machine was distortion of the diaphragm in the eighteenth stage, causing it to foul the eighteenth wheel, breaking off the blades, after which complete damage to the remaining low-pressure stages and casing followed. The Boston machine was carrying a full load just before the wreck, and at the time of the accident was likely carrying a great overload momentarily, owing to an electrical blowout in another station tied in to the same system which the damaged turbine was serving.

[1]Detailed description of this accident appears in *Power*, Mar. 19, 1918.

The Chicago machine carried no load at the time it went to pieces, but had been in service, all day. It was taken off the line shortly after midnight, July 31, preparatory to cleaning the condenser, and, as is the usual good practice, the crew immediately arranged to give the machine its regular monthly overspeed run to test the automatic stop governor.

The overspeed test is given by the operator, who pulls up on the governor lever. This was being done when the accident occurred. The generator is of 25 cycles. The switchboard operator states that the speed at which the turbine began to be demolished was that which gave but 26½ cycles, or less than the customary 10 per cent. allowed before the automatic overspeed stop governor functions. The speed corresponding to 26½ cycles is about 6 per cent. above the normal speed of 1500 r.p.m., or 1590 r.p.m. When the overspeed test was made on June 1 the speed reached 28 cycles, or 12 per cent. above normal. The operator tripped the throttle by hand when he saw that the automatic stop did not function at 27½ cycles. On the July 1 overspeed test the automatic stop governor tripped the throttle at 27½ cycles.

At the time of the wreck the conditions were ideal for observation of the behavior of the machine, for correct reading of the tachometer by the men at the turbine and of the frequency meter by the switchboard operator. There was no emergency, there were no unusual conditions; in fact, if the stage had been set for observation of the demolition of the machine, it could not have been better set. The builders understand that the voltmeter pointer was hard over against the extreme stop, and at this writing are attempting to determine at what speed the generator would have to run to create such voltage.

At the time of the wreck the steam pressure was 240 lb. There is comparatively little load on the station at this hour of the morning. The throttle was, of course,

wide open. The watch engineer was standing at the throttle while the overspeed test was being made. Nothing unusual was happening. Suddenly there came a thump, severe vibration, and a crash as the low-pressure casing burst and pieces of metal and blades flew about the room. The man at the throttle tripped it as he saw the low-pressure casing burst.

A heavy piece of metal careened across the room, flying over and clear of the 30,000-kw. Curtis turbine which was in service, knocking away a panel of the house switchboard.

In the ventilators near the roof a heavy piece of metal lodged. The glass roof is perforated in numerous places, where fragments of metal were hurled through.

governor was knocked away completely from the turbine. Housings for the three bearings for the turbine, that is, that at the governor end, or No. 1, and the two (Nos. 2 and 3) between the turbine and generator, shown in the longitudinal section below, all are broken.

The bedplate beneath the outboard-bearing pedestal is cracked. The housing at the bearing on the high-pressure end has been torn away where its flanged bottom was bolted to the bedplate. The flanged bottom of the bearing housing is tilted up in the direction of rotation of the shaft.

In the Boston wreck no wheels, except a very small piece out of the last wheel, were broken though they were subjected to severe jamming. The next to the

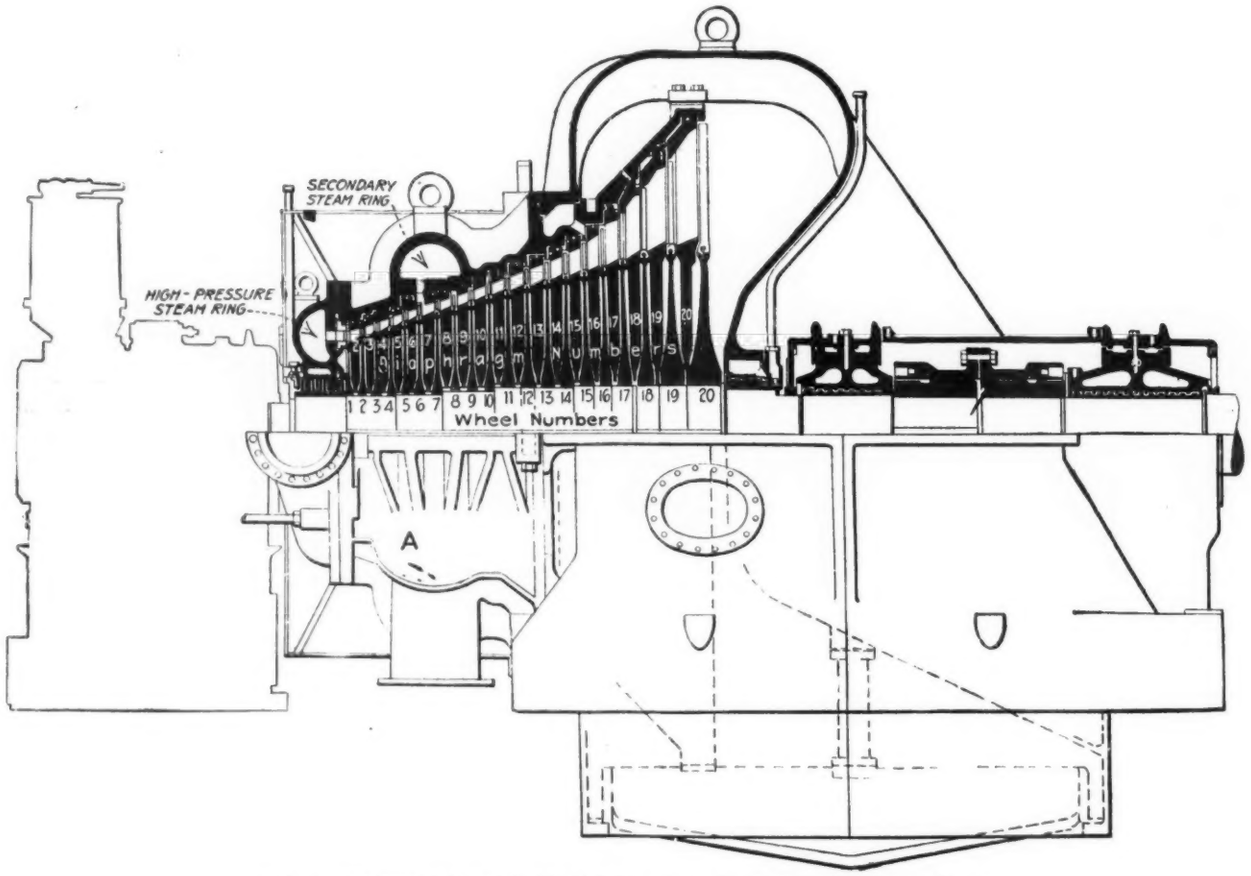

SECONDARY STEAM RING
HIGH-PRESSURE STEAM RING
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Diaphragm Numbers
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Wheel Numbers
A

FIG. 1. SECTION OF THE 35,000-KW. TURBINE WRECKED AT CHICAGO

A piece of metal from the damaged machine was thrown in through the glass front of the switchboard gallery, barely missing the bench or control board. The operator was standing at his controls at the time this piece of metal went up and by him. It landed near his feet, knocking away the floor on which he was standing, and he dropped through this opening onto a false floor, about 2 ft. below. He is uninjured. Many fragments of metal went through the partition into the washroom, but none of the men in there at the time was injured.

The significant facts relative to the damage to the turbine are these: The cast-iron low-pressure casing is blown away, from the 18th wheel on. The high-pressure casing, made of cast steel, is cracked, chiefly below the reinforcing webs at *A*, Fig. 1. The diaphragms in the last low-pressure stages are broken up; the semistee cone supporting these diaphragms is demolished. The

the last low-pressure wheel of the Chicago machine, or the 19th wheel, has a piece 36 x 30 x 12 in. broken out of is as shown in Fig. 2. The breaking of this wheel is the most significant feature of this accident. More about it later.

The top or the periphery of the last (20th) low-pressure wheel particularly is bent so that it presents a wavy line. About one-quarter of the number of blades on this wheel were torn away and the remainder are badly bent.

Some blades remain on all the wheels that are visible. The turbine at this writing has not been opened up, therefore we do not know the condition of the high-pressure end of the rotor.

The shrouding on the last low-pressure wheel is, of course, gone. Incidentally, it is enlightening to know that some weeks ago the shrouding on the third from

the last low-pressure wheel, or the 17th, got loose from the blades. The blades were cut down and new shrouding put on.

Pieces of diaphragms and pieces of the great cone supporting the low-pressure diaphragms, Fig. 1, fell into the condenser, crushing the tubes for several rows from the top row. The support for the bearing at the exhaust end of the turbine was not fractured, but the bolts holding it were loosened. All the nozzles in the 20th diaphragm were knocked away and the ring holding the tops of the nozzles was broken.

The violent vibration and backlash of its gears likely shook the governor completely from its position. It is reasonable to presume that it was not knocked away by being hit by a piece of metal. It was farthest from the low-pressure end where such pieces started on their flight, and is in a direction at right angles to the that taken by these flying pieces. However, one will recollect that at Boston four large pieces of metal went through the end wall of the turbine room near the roof. This is in a direction at right angles to lines drawn radially from the turbine rotor, or from the direction that most of the flying pieces of metal went.

The breaking of the bedplate near the pedestal for the outboard bearing excites inquiry. There are two bearings, Nos. 2 and 3, between the low-pressure casing and the main generator, one on each side of the flexible coupling. When the housings for these bearings broke, the shaft was not held rigidly except at its extreme ends, that is, the high-pressure end and the outboard end. The generator rotor, weighing many tons,

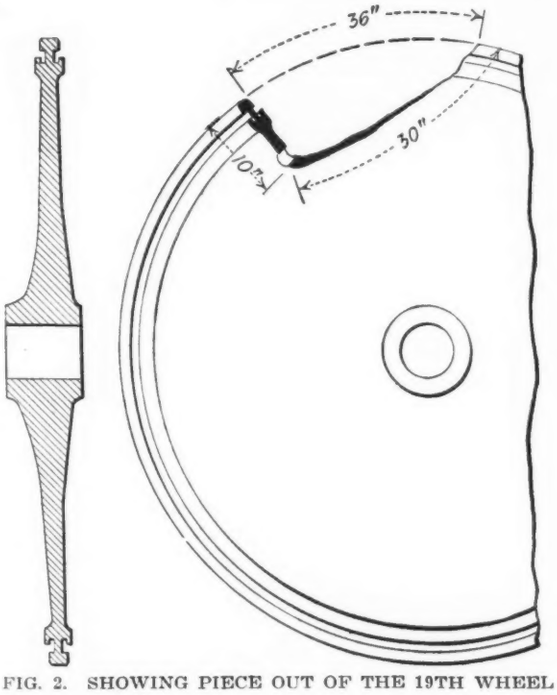


FIG. 2. SHOWING PIECE OUT OF THE 19TH WHEEL

revolving at least 1500 r.p.m. would naturally tend to spring the shaft and cause it to whip, and this would likely put stress on the bedplate sufficient to fracture it. This assumption invites credence because the bedplate where it is cracked is raised from its normal position.

To return to the broken 19th wheel, the most significant feature of the wreck. The piece broken out is of the shape and relative size shown in Fig. 2, and weighs about 200 lb. A natural inference is that this was the first part of the rotor to let go, and that its letting go precipitated the wreck. A portion of the piece was taken to the builders' shops at Schenectady for examination and they say the metal shows no defects.

The wheels are of forged steel, tensile strength 130,000 lb., elastic limit 73,000 lb. The 19th wheel is about 8 ft. in diameter and is shaped as shown in section in

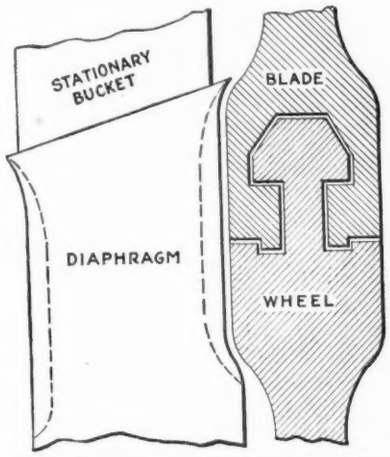


FIG. 3. DOTTED LINE SHOWS HOW DIAPHRAGMS WERE CUT AWAY

Fig. 2. Ordinarily the temperature of these wheels when the machine is in service is that corresponding to the vacuum in which they revolve. When running without load, however, the temperature may vary from about 95 deg. F. to 200 and 300 deg. F. We do not presume to question the accuracy of the designer's calculations relative to these wheels. We do, however, remember that when this design of turbine was first brought forth, the Massachusetts Institute of Technology was engaged to check the stresses in the wheel, that in this particular wheel (one from the Boston turbine, they found the factor of safety to be four, and that the professors did express it as their opinion that because of the shape of the wheel fracture might develop if it was subjected to sudden extreme temperature changes.

It is possible that the wheels of the Chicago machine were subjected to temperature changes at the time of the wreck, as the machine had been carrying its usual load, and it was only two or three minutes from the time the load was taken off until the damage was done.

Besides the symptoms audible immediately previous to the turbine letting go—that is no undue vibration, but one violent thump being the first indication of trouble—there is other evidence that the wheel was the first part to break; and incidentally this evidence seems to show that the blades on the last two wheels did not let go first, and by centrifugal force alone, as was current rumor in the days immediately after the accident. An explanation, given in the following, is necessary here:

Reference to Fig. 3 shows how these last low-pressure blades are mounted on the shaft. The clearance between the diaphragm and the wheel is ordinarily ⅛ in.; but in the Chicago machine the diaphragms were cut away as shown by the dotted line to give sufficient clearance to allow for two possibilities, namely, dis-

tortion of the diaphragm, and failure of the wheel to preserve rigidity at its rim. The peripheral speed is about 1000 ft. per sec. for these last wheels. Therefore when rubbing of the diaphragm against the wheel occurs, the base of the blades is burned away at the fastening. There is no evidence of such rubbing in the Chicago machine. Many of the blades have the appearance of having been struck a heavy blow, and it is likely that this blow, together with the centrifugal

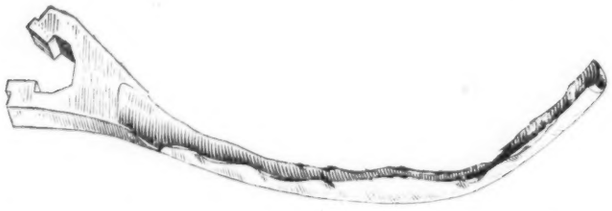


FIG. 4. TYPICAL BLADE FROM THE DAMAGED CHICAGO MACHINE

force, tore them from their fastenings. Fig. 4 represents a typical low-pressure blade from the Chicago machine. Note that they appear to have been wrenched away from the wheel.

At this writing no examination of the thrust bearing has been made. The adjustment to the thrust bearing, as it is indicated by the indicator for this purpose, reveals no change in the position of the bearing.

After the Boston accident, all turbines of this type had their secondary valves locked by the builders, thus limiting their load. The Chicago machine had its load limited to 28,000 kw. maximum.

Saving Due To Soot Cleaner

Some interesting computations have recently been made by the Vulcan Soot Cleaner Co., of Du Bois, Penn. They find that each foot of pipe used in connection with a permanently installed soot cleaner saves approximately 18.3 tons of coal during the lifetime of the cleaner; also, each foot of pipe saves one man's labor for one day.

Since the average water-tube boiler requires about 200 ft. of cleaner pipe, it is not difficult to compute the total money saved or the money saved by the reduction of labor cost alone. Wages at the present time are high, but if boiler-room labor can be secured at $2 per day, the labor saving with the average cleaner is $2 $\times$ 200 = $400 for the lifetime of the cleaner. Again, assuming the price of coal to be $4 per ton and 200 ft. of pipe per cleaner, the coal saving for the lifetime of the cleaner will be $4 $\times$ 18.3 $\times$ 200 = $14,640. Adding this to the labor saving, the total saving is about $15,000. The figures vary with labor and coal cost, but can be easily adjusted to fit conditions. They are based on boilers operated at 140 per cent. of capacity, average coal consumption 4 lb. per boiler horsepower per hour, boilers operating 24 hours per day, 325 days per year.

It is also assumed that the life of a Vulcan cleaner is seven years. The manufacturers point out that five years ago cleaners were installed on 32 B. & W. boilers in the plant of the United Electric Light and Power Co., New York City, totaling 20,000 hp. During these five years only 36 nozzles were bought and placed in stock for emergency use. Very few of the nozzles have been used to date, which may be considered a very good record indeed, and shows that seven years as the life of a cleaner is a conservative assumption. As now made, the cleaners have a still higher safety factor than those installed five years ago because of the cast-iron sheathed elements with which they are now equipped. The elements in the plant of the United Electric Light and Power Co. just mentioned, are uncovered, untreated, unprotected and absolutely bare to the high temperatures, yet they appear to be as good now as when first installed.

Discriminating Between Power Consumers

On the right of a consumer of electric-power service to sue for damages sustained through discrimination against him by a public utility furnishing the service, the United States Circuit Court of Appeals, Eighth Circuit, said in the late case of Homestead Co. vs. Des Moines Electric Co., 248 Federal Reporter, 439:

It is the duty of a public-service corporation, lawfully authorized to use the streets and public places of a municipality in order to furnish to consumers water, gas, electricity, light, heat, power, or any other public utility, to render like contemporaneous service for like compensation to consumers conducting like operations under like conditions and circumstances. For unjust discrimination between competitors, and substantial injury to one of them caused by a breach of this duty, the injured competitor may maintain an action against the public-service corporation for the pecuniary loss inflicted upon him by such discrimination. . . .

A public-service corporation furnishing its utility under and pursuant to an act of the legislature of a state, or under a lawful ordinance of a city, or under other legal provision, which prescribes maximum rates for its service, may fix its own rates, not exceeding the limit thus prescribed, and such rates are presumed to be reasonable. Individuals interested therein as consumers, users or otherwise may not maintain actions at law or suits in equity against the public-service corporation, on the ground that such rates are unreasonable, without having first secured decision or action to that effect by the public tribunal authorized to prescribe the maximum limit of rates changing the limit, or adjudging the rates complained of unreasonable.

Second Nitrate Plant Nearing Completion

The second Government nitrate plant situated near Sheffield, Ala., is nearly completed, and the general indication is that two units of the $30,000,000 plant will be turning out nitrates by October at the latest. Its capacity is 133,000 tons of nitrates for gunpowder, or 220,000 tons of fertilizer concentrates, says the *Birmingham Ledger*.

As the Government could not wait on the water power, which depends on the construction of dam No. 2, which in turn will require three to four years to complete, there has been built at plant No. 2 a steam-power plant, with a capacity of 120,000 horsepower and at plant No. 1 a steam plant with 6000 horsepower, while transmission lines from the steam plant of the Alabama company on the Warrior River bring from a distance of 90 miles 30,000 horsepower. By October an additional unit of this Warrior plant will have been completed, and there will be 30,000 more horsepower, making a grand total of 186,000 horsepower created in the steam-power plants for present operations and for emergencies and as auxiliaries after the water-power project has been completed.

Graphic Method of Chimney Design

By H. M. BRAYTON

A method of designing chimneys without calculations. This is done by combining long and complicated formulas and expressing the results in the form of curves. Thus the solution of a chimney problem, with the exception of the stability, is obtained by charts.

THE design of large chimneys for power-plant purposes may conveniently be divided into three general heads, as follows: First, the determination of the proper height to give the desired draft; second, the determination of the best inside diameter or inside cross-sectional area; and third, the stability of the structure. It is the first two of these points which will be dealt with here, as the third is simply a problem in mechanics.

Draft Not in Direct Ratio to Chimney Height

Most handbooks on mechanical engineering give formulas by which the height of chimney needed to give any desired draft may be found if the temperature of the flue gases and that of the outside air are known. It will be noted that all these formulas show that the draft varies directly with the height of the chimney; or in other words, a chimney 200 ft. high will give a draft just twice that of a chimney 100 ft. high. It is known that this is not true, and it is also a fact that not many chimneys are ever built over 250 ft. high. A few have been erected to 300 ft. in Europe, but it is believed that the small amount of additional draft gained was not worth the added expense over that of the lower chimney.

Back in 1911 and 1912 a long series of experiments were carried out on the big 250-ft. chimney of the Boston Edison Co. at the L Street Station in South Boston. Temperature readings at various heights within the chimney were taken, and a curve of the average results was plotted. This curve, Fig. 2, shows very clearly that the relation between the temperature and the height of the chimney is not a straight line. The curve seems to approach the vertical toward the top, which would account for the fact already noted that it does not pay to build chimneys over 250 ft. in height. The next step was to determine the equation of this curve and this was found to be an exponential of the form.

$$HT^n = K$$

in which

H = Height of chimney, in feet, at any point above center line of flue;

T = Absolute temperature of flue gases, in degrees Fahrenheit, at the point considered;

$n = 25$;

K = A constant whose logarithm is 75.4032.

If this formula is written in the logarithmic form, it becomes

$$Log\ H + 25\ log\ T = 75.4032$$

Having this equation, the draft that any given chimney will afford may be determined; or, conversely, the proper height to give any desired draft may be calculated. The latter case is the one most often met with in practice. This calculation is carried out by first getting the area under the curve, as shown cross-hatched in Fig. 2, and from this the average temperature throughout the chimney. By assuming the temperature of the outside air, it is then possible to determine the available draft from any given chimney.

If the height of chimney is desired, it becomes necessary to assume a height and go through this calculation, and in case the first assumption is not correct, another must be made, and so on until a chimney that

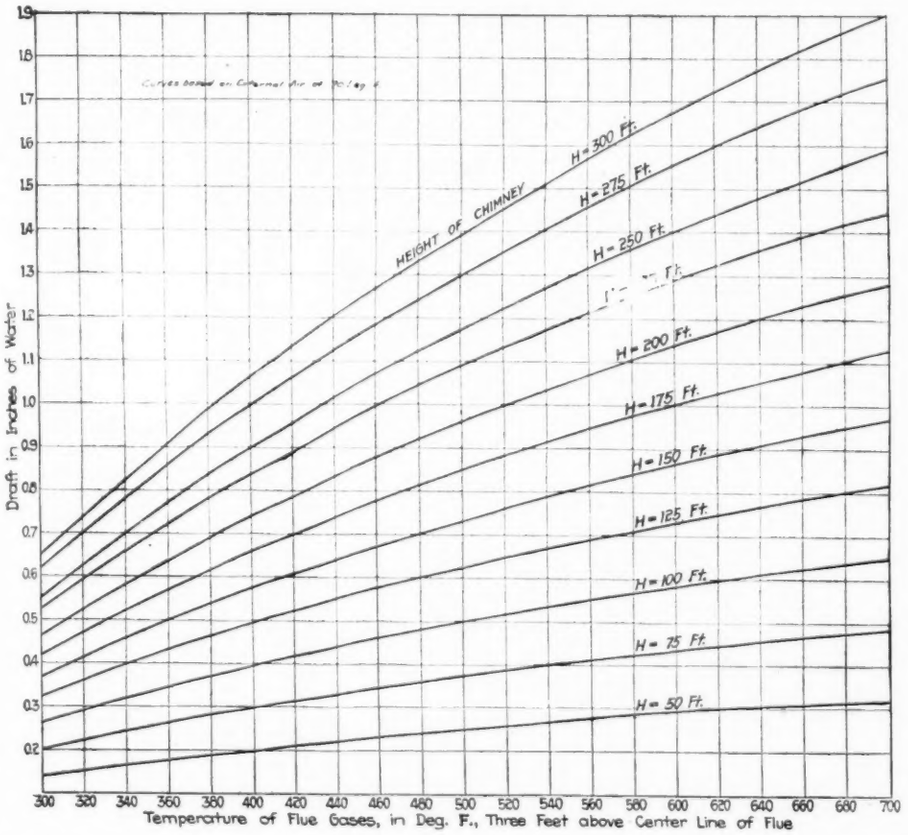

Draft in Inches of Water
HEIGHT OF CHIMNEY
H = 300 Ft.
H = 275 Ft.
H = 250 Ft.
H = 200 Ft.
H = 175 Ft.
H = 150 Ft.
H = 125 Ft.
H = 100 Ft.
H = 75 Ft.
H = 50 Ft.
Temperature of Flue Gases, in Deg. F., Three Feet above Center Line of Flue

FIG. 1. RELATION OF DRAFT, FLUE-GAS TEMPERATURE AND HEIGHT OF CHIMNEY; EXTERNAL AIR AT 70 DEG. F.

will give the desired draft is obtained. This, to say the least, is a long and laborious calculation, and to shorten the work the writer devised the scheme of combining the equations used and eliminating the average temperature entirely, thus leaving only three variables, namely; the height of the chimney, the temperature of the flue gases at the base of the chimney and the draft in inches of water.

Fig. 1 shows this plotted in a form to be used quickly and without calculation. The three variables have been reduced to two by assuming different values for the height of the chimney and plotting a separate curve for each. It will be noticed that the temperature of the outside air was taken at 70 deg. F., which was believed to be a fair assumption. To use this chart it is simply necessary to find the desired draft on the vertical scale and the temperature of the flue gases on the horizontal scale and follow horizontally and vertically to their intersection. The proper height of chimney is marked on the curve above the intersection.

It can be seen, then, that this problem may be solved with the aid of the chart without any calculations. It not only is a time saver, but also helps the practical man who may not have the mathematics fresh in his mind. The writer used this chart in power-plant design work at college and found it useful there.

The second point in the design of chimneys, namely, the determination of the inside diameter, will be considered next. This is usually given by the formula,

$$E = \frac{3C}{50\sqrt{H}}$$

in which

E = Inside cross-sectional area of chimney in square feet;

C = Pounds of coal burned per hour per boiler horsepower;

H = Height of chimney, in feet.

If we assume a value of $C = 5$ lb. of coal per boiler horsepower per hour we have from the above equation

$$E = \frac{3P}{10\sqrt{H}}$$

in which P represents the boiler horsepower.

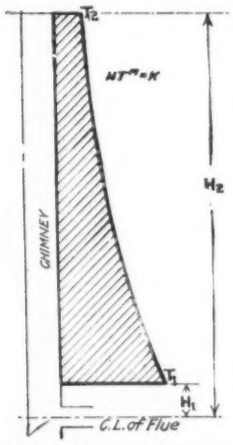


FIG. 1. CHIMNEY-TEMPERATURE CURVE

From one of these two equations it is possible to obtain the necessary chimney diameter after the height of the chimney has been determined by the method previously outlined. Fig. 3 shows a chart for solving these two equations without calculation. This chart solves either equation for E, depending on whether the value of C or P is known.

To use the chart it is simply necessary to connect the two known variables with a line or ruler, as shown by the dash-pot line. The third variable will then be read off where this line crosses its scale. As an example, assume that the values of C and H are known. Take $C = 10{,}000$ lb. and $H = 150$ ft. Then, as shown on the chart, a line connecting these values will cut the diagonal scale at a value of $E = 50$ sq.ft., nearly, or a chimney with an internal diameter of about 8 ft. In a similar manner the result may be found when H and P are known and P is taken at 2000 boiler horsepower.

Thus, by means of these two charts it is possible to determine the proper height and cross-sectional area of

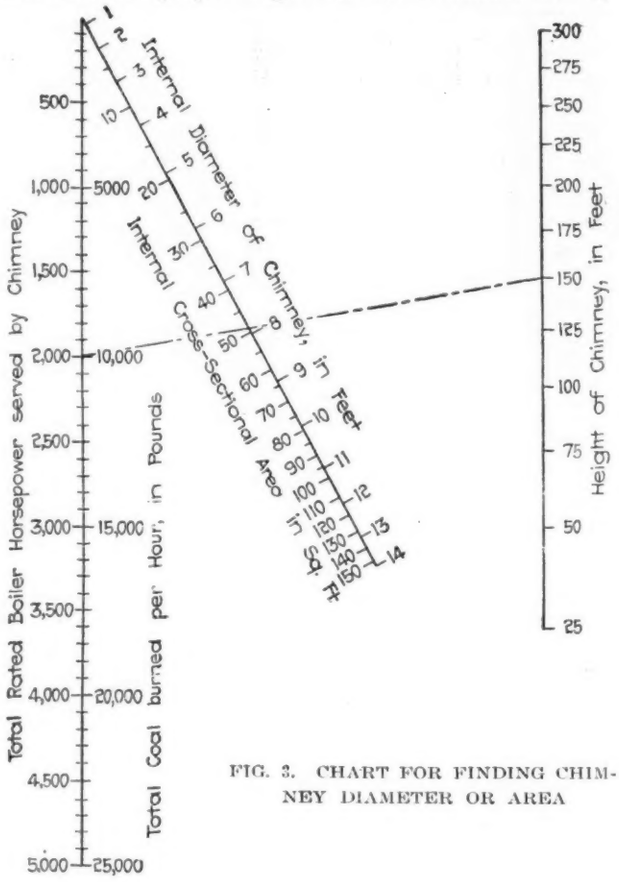


FIG. 3. CHART FOR FINDING CHIMNEY DIAMETER OR AREA

a chimney without any calculation at all and in a very short time. These charts should be a great time saver in any drawing room where power-plant design is handled or where this kind of work is dealt with.

Water-Power Rights

A water-power corporation that has delivered to the proper county officer maps, plats, etc., covering a water-power location has "filed" it and has thereby become vested with superior rights to that location, regardless of whether or not the officer has marked the papers "filed."

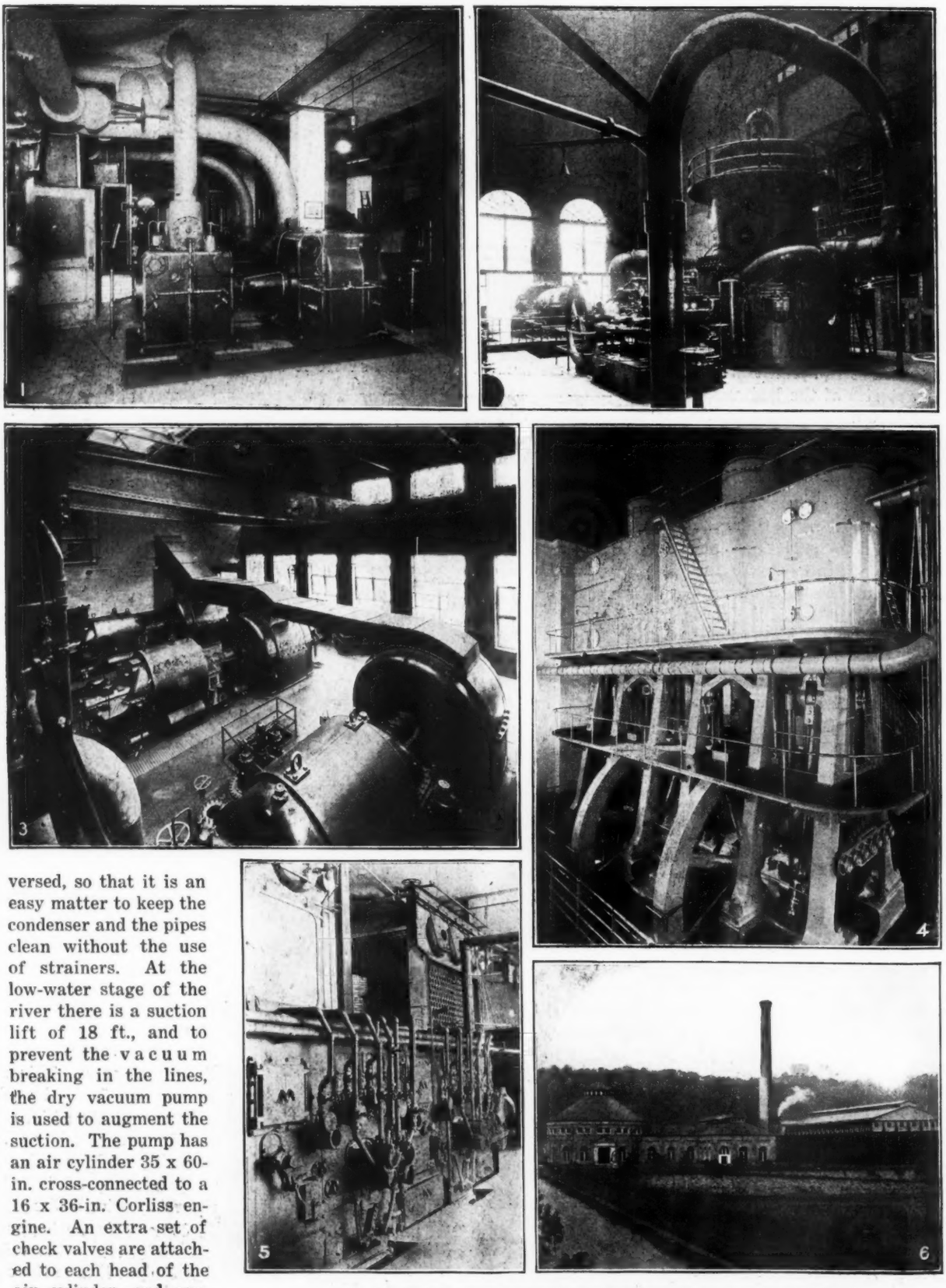
Under the constitution of North Carolina, the legislature may confer upon a power company or other public-service corporation the right to condemn necessary lands without granting the same power to other corporations of the same class. But legislative grant of the power to condemn is necessary; the mere fact that a power company is a public-service corporation and owns riparian lands gives it no implied authority to condemn.

That a water-power company has failed to comply with a statutory requirement limiting the time for the beginning of development work does not give rights to a competing company; the omission can be taken advantage of by the state only. (North Carolina Supreme Court, Carolina Tennessee Power Co. vs. Hiawassee River Power Co., 96 Southeastern Reporter, 99.)

Plants and Places in Cincinnati

CINCINNATI is a city especially interesting to engineers. It is one of the largest machine-tool manufacturing centers in the country, and much power-plant equipment is made there. The mechanical laboratories of the University of Cincinnati, of the Ohio Mechanics Institute, the various power plants, and the institutions devoted to the fine arts, should engage the interest of those who attend the convention of the National Association of Stationary Engineers during the week of Sept. 9 to 15. In the Mill Creek Valley northwest of the business district are the three big valve-manufacturing companies: Lunkenheimer, Wm. Powell and D. T. Williams. Farther out in the same direction is Ivorydale, the home of Ivory soap, which has an enormous power plant. The Philips Carey Co., makers of asbestos products, the Richardson Paper Co. at Lockland, and the Laidlaw-Dunn-Gordon branch of the Worthington Co. at Tweedville are other places of engineering interest. Among other large works at Norwood is the Bullock Works of the Allis-Chalmers Manufacturing Co. Across the street from the Sinton Hotel is Cincinnati's famous skyscraper, the Union Central Life Insurance Co. Building, Fig. 1. The power plant has been described previously in *Power*. It is an interesting place to visit, and as central-station current is being used part time, the engineer, C. B. Garrison, may have some useful information to impart. Not far away is the new plant of the Union Gas & Electric Co., described on other pages of this issue. A mile or so north is the the Plum Street plant of the company, which has a capacity of 40,000 kw. in twelve units. One of the attractions here is the largest commutator in the country. It has a circumference of 53 ft. and serves a 2500-kw. direct-current machine. Both coal and natural gas are burned and in some cases the two fuels in combination. N. T. Rouse is chief engineer. The power plant of the Moerlein brewery is indeed interesting. The engines exhaust into a 300-kw. low-pressure turbine. Considerable ice is made and 2,400,000 cu.ft. of space is refrigerated. C. W. Heath is chief engineer. East End Station of the Cincinnati Traction Co., formerly known as the Pendleton Station, is another plant of particular interest. William Mittendorf of the local committee, is the mechanical engineer. The plant generates 6600-volt, 25-cycle, three-phase current which in rotary converter substations is converted into 550-volt direct current for street-railway service. It has three 6000-kw. double-flow turbo-generators. The novel feature of the plant is the circulating water supply for the condensers. This supply is taken from the Ohio River through six 36-in. cast-iron pipes, one pair or two pipes being used for each unit. Each pair of pipes is bolted to a reversing valve at the plant. A 25,000-gal. circulating pump is also attached to the valve, and two pipes lead to the condenser. By operating the reversing valve, which is done hydraulically, the direction of flow of the water can be re-

FIG. 1. THE UNION CENTRAL BUILDING



versed, so that it is an easy matter to keep the condenser and the pipes clean without the use of strainers. At the low-water stage of the river there is a suction lift of 18 ft., and to prevent the vacuum breaking in the lines, the dry vacuum pump is used to augment the suction. The pump has an air cylinder 35 x 60-in. cross-connected to a 16 x 36-in. Corliss engine. An extra set of check valves are attached to each head of the air cylinder, and connection is made through a 4-in. pipe to the large

FIG. 2. SOME OF CINCINNATI'S INTERESTING POWER PLANTS

1—Engine Room, Union Central Building. 2—Turbine Room, Plum St. Station. 3—Turbine Room, East End Station. 4—Triple-Expansion Pumping Engine, River Pumping Station. 5—Boiler Fronts, General Hospital. 6—One of the City's Large Pumping Stations.

FIG. 3. GENERAL VIEW OF THE UNIVERSITY OF CINCINNATI WHERE THEORY AND PRACTICE ARE INTERWOVEN

inlet lines from the river. When the vacuum in the cylinder exceeds that in the suction line, the check valves open, so that additional lift for the cooling water is provided for a portion of each stroke of the air pump. This scheme has been in satisfactory operation for a number of years. The plant was designed by Thomas Elliott, formerly chief engineer and now vice-president of the Cincinnati Car Co.

Of the municipal and county buildings the new court house is the latest. During the convention the power plant should be ready for inspection.

The Cincinnati General Hospital, erected at a cost approximating $4,000,000, is one of the best equipped of its kind in the world. It has its own power plant with boilers equipped to burn coal or natural gas (see Fig. 2), and some interesting piping in connection with the boilers and the forced-circulation hot-water heating system employing both live- and exhaust-steam heaters.

Those who attended the previous convention in Cincinnati in 1911 will remember the elaborate waterworks system involving an expenditure up to the present writing of $20,000,000. The total capacity of the system is 128,000,000 gal. per day. It consists of three pumping stations and a filtration plant which delivers water over 99 per cent. pure from the turbid Ohio River. River Pumping Station and the filtration plant are located in the village of California on the Ohio River, about 7½ miles above the Suspension Bridge. It is a fifty-minute trip from the hotel, but according to

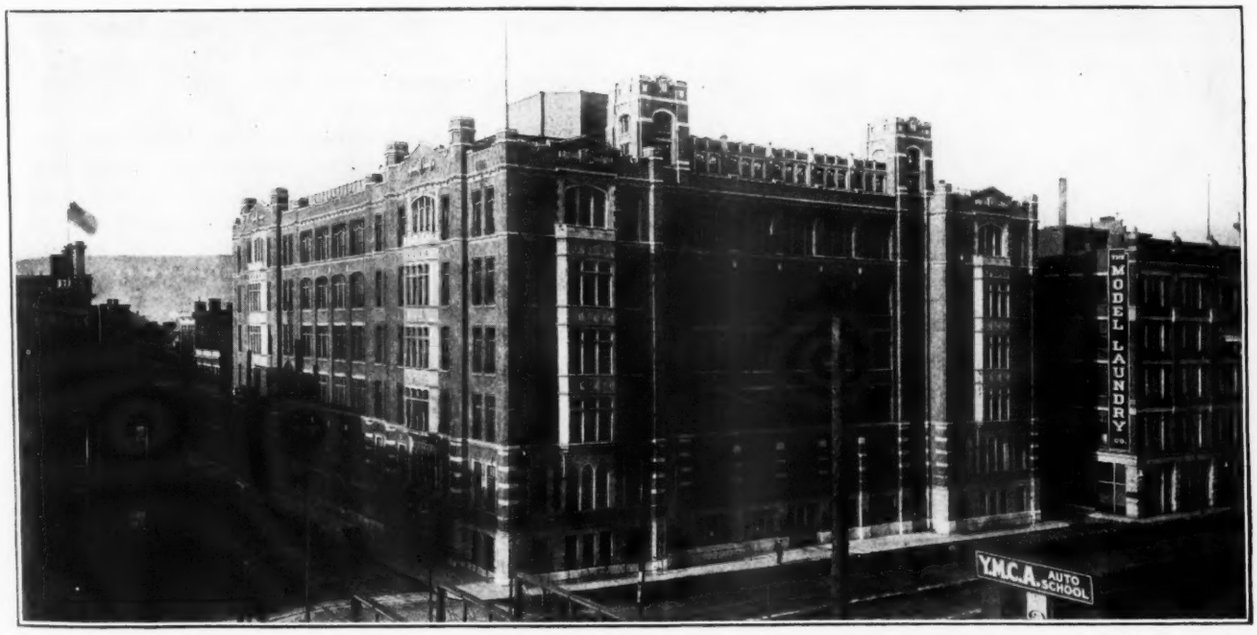


FIG. 4. MECHANICS INSTITUTE. ONE OF THE CITY'S FINE TRADE SCHOOLS

C. H. Anderson, mechanical engineer of the pumping division, well worth the time spent. At the River Pumping Station there are four 30,000,000-gal. vertical triple-expansion pumping engines, placed radially around a central shaft from which they receive their water, in an enormous pit 98 ft. diameter and 85 ft. deep. It is the only construction of the kind in the world. Above the pump pit deck each unit has an extreme height of 106 ft. and weighs 1500 tons. Main Pumping Station is much nearer the city. It is here that Mr. Anderson has his office. He will welcome visitors, but in these war times a pass should be procured from the superintendent, Mr. Hiller, at the City Hall. Two systems are supplied by the station—one a high-pressure at 195 to 210 lb. and the other a low-pressure system at 75 to 85 lb. The latter is served by three 25,000,000-gal. vertical triple-expansion pumping engines and the high-pressure system by three 12,000,000-gal. units of the same type and a 17,000,000-gal. pump installed since 1911. The steam end, with cylinders 38, 72 and 110 by 66 in., is among the largest in the country. Steam at 160-lb. pressure is supplied by water-tube boilers equipped with underfeed and top-feed stokers and economizers. There is also provision to burn natural gas under the boilers.

A Built-up Indicator Diagram

BY F. L. JOHNSON

On a recent business trip I passed near the old home town and decided to make a week-end stop. One of the first things that met my eye as I crossed the little square between the railroad station and the hotel was Simons' gold lettered sign, "Emergency Engineer" in the same window where he put it six years before. Business must have been fairly good or the sign would have been taken down. I went in and as he greeted me I noticed that his glance was as alert and his manner as quick, reliant and decisive as of old.

As I took the chair he offered me he said, "I am glad you happened along just at this time for I have something in the indicator diagram line (Fig. 1) that I want you to see. This diagram came from Colter's and

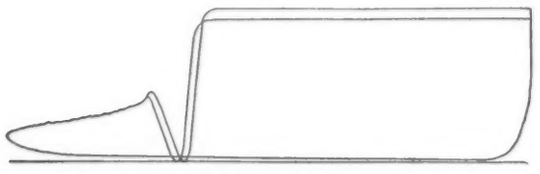


FIG. 1. ORIGINAL DIAGRAM

the engineer asks what he will do to the engine to get the right kind of a card." While I was examining the diagram he continued, "Do you remember the lecture on natural history that we attended together when the professor showed how an entire skeleton of a prehistoric animal could be delineated from a single bone and how he illustrated this by an old chair leg picked up on the sand near Fort Hamilton? How on the blackboard he first drew a picture of the leg with the holes in the sides for the rounds and the tenons at the ends for the seat and the rocker, and then how he went on putting rounds into the holes and seat and rocker on the tenons and then more legs, another rocker, arms and a back and the chair was complete? Well, I applied the professor's method of reconstruction to this diagram. You will notice that the compression curve and a part of the expansion line have the ear marks of relationship to a 'really and truly' indicator diagram. The balance is worthless and might as well have been made on a typewriter for all the engineering value it has.

"Now, if you will look at this sheet (Fig. 2) you will see how the professor's method of reconstruction was applied. At the right distance below the atmospheric line the vacuum line was drawn, then from the fragment of the expansion line and the terminal pressure, the clearance line and the approximate point of cutoff

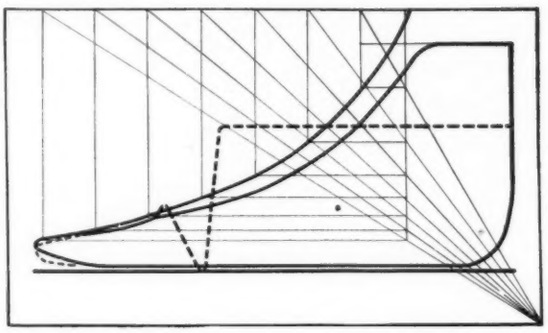


FIG. 2. RECONSTRUCTED DIAGRAM

was established and the hyperbolic curve drawn. The completed diagram tells very nearly the story that the indicator tried to tell but was not allowed.

"In this particular case, and which, by the way, I have found is not an uncommon one, the engineer did not understand the indicator any better than he did the engine. From the scale of the spring it is readily seen that the pencil did not rise much more than half way to the boiler pressure line. At this point the piston stuck in the indicator cylinder for two-thirds of the stroke and then let go. The unbalanced tension of the spring started the pencil downward at a high velocity and inertia carried it to the atmospheric line. Steam pressure under the piston carried it back to its true position but inertia again moved it beyond, though only slightly, because its rise was much slower than the descent. From this point to the end of the stroke and back to the admission line the diagram is a reasonably truthful story of conditions in the engine cylinder.

"Too much emphasis cannot be placed on the importance of an intelligent interpretation of indicator diagrams. At the best they are not accurate and when distorted by irregular reducing motions, stretching and whipping cords, friction of piston and pencil, lost motion and inertia, they make one's heart ache.

"Not so very long ago I was asked to check the results of an alleged test where the length of the diagrams varied by more than one-quarter of an inch and some showed plainly that the indicator drum struck the stop at one end of the stroke. Of course, I returned the diagram for the reasons stated.

"Let's stop this right here and go to dinner. I could talk all night over this and then only get started, besides we have so many other things to talk about." He closed the office and together we went to his home where after dinner we spent some hours in reminiscences.

EDITORIALS

Steam-Turbine Failures

ANOTHER large turbine has been wrecked, this time at the Northwest Station of the Commonwealth Company in Chicago. Only five of the type have been built, and of these one went to pieces at Boston last February. There is naturally much discussion and concern as to whether the failures were due to common or similar causes, and if so, whether such causes are inherent in the design or were induced by some condition of operation.

In order that it may have a reasonable length of blade without too much entrance area, the first disk of a turbine must be comparatively small. On the other hand, in order to pass the enormous volume of the highly attenuated exhaust steam without impractically long blades, the last disk must be large.

In order to keep the number of stages down and get a large output out of a small investment without sacrificing efficiency, it is necessary to have a considerable bucket speed in the early stages. This, on account of the small diameter of the initial disks, requires a high rotative speed, which produces in the relatively large final disks, if attached to the same shaft, a very high peripheral speed; in the case of the Boston and Chicago turbines something like a thousand feet per second.

An alternative is to split the turbine after the disks have got to a size which will give a comfortable rim speed and finish the expansion in a low-pressure section running at a slower speed. This, however, involves a second generator and more than twice the weight per horsepower for the slower turbine, with an enormous increase of cost, which is enhanced by the cost of the greater space required to house the double machine. The low-pressure section can also be split upon the same shaft, but this involves more turbine.

Experts who checked the design of the wrecked turbines gave it a factor of safety of four so far as centrifugal stresses are concerned, but referred to the possibility of stresses being set up by unequal expansion through sudden changes of temperature. It is significant that both of these accidents occurred immediately after changes in operating conditions which involved a considerable temperature change in the low-pressure end—the first to the sudden imposition of an excessive load, the second to the taking off of the load. The initial failure in the first case was apparently in the diaphragm or stationary member; in the second case, in the disk or rotating member.

In view of the foregoing, the interest which attaches to the demonstration of the practicability and safety of the simpler high-speed type may therefore be appreciated, and the engineering world, the users of turbines, and the public, the big user of their product, will be very sympathetic with the effort to develop it and very tolerant of the failures incidental to such development provided the causes of such failures are determined, frankly acknowledged and removed or guarded against. The makers of these turbines are searching for the reasons for their failure with an appreciation of this interest, and in this spirit, and we hope eventually to be able to give the results of their investigations.

The determination of the cause of an accident to a turbine—and this applies rather to the occasional accidents to small turbines than to the exceptional cases under review—will usually reveal that the machine was of some unusual type or that there was some derangement, as of the governor, or gross mismanagement. The turbine in any of the standard forms into which its manufacture has crystallized is as safe under competent supervision as any other type of prime mover.

Why Not Change to Night Work?

SINCE the United States entered the war against Germany, there has been such an increased demand for power for essential industries as to place a heavy burden on many of the power houses throughout the country. Owing to the heavy power requirements, the daily load in many cases is greatly in excess of the plant's capacity, and some method must be worked out that will enable the power loads to be more evenly distributed over the twenty-four hours.

When a station is running continually on a heavy overload, there is danger of a total failure of the power. No matter how rigidly a machine may be made, time must be given for repairing and overhauling. Not only does the mechanical factor enter into the question, but the endurance of the men in the plant must be considered. Men can work at high speed for a time, but there is a limit to their endurance and during the hot summer days the extreme heat added to the arduous work of the boiler room is more than human strength can withstand. As a matter of fact, during the recent hot spell power plants were crippled because the regular force of workmen were absent or incapable of performing their daily duties.

There are remedies that can be applied to relieve this condition of power shortage. The main one is to canvass the factories served by such overloaded plants and ascertain what portion of load that is being used during the day can be changed to night operation.

Most power plants have at night a surplus of capacity which is available for operating equipment that is now being run during the day, and if arrangements could be made to change some of the existing day load to night load, the relief to the power plants would be well worth the inconvenience that would fall to the lot of those who would be forced to change from day to night labor.

Another way to gain a partial relief is for each user of electrical energy to conserve. It is easy for a workman to get into the habit of allowing his machine to run when no work is going through rather than to

take the trouble to stop it and start up again when ready to proceed. Lights are burned each day, hundreds and thousands of them, when they are not really required just because it is nobody's business to turn them off. Let each one make it a part of his business to see to it that electric lights are not needlessly burned.

Building new power plants will not wholly remedy the shortage of energy, as more coal will be required, which necessitates more mine output, already behind the demands, more tonnage for the transportation lines to handle and more men to handle the fuel during its various stages from the mine to the boiler furnace.

Changing from day to night work should not be considered as a matter of convenience but as a duty under existing conditions, and a man or a manufacturing company can be as patriotic by so doing as by shouldering a rifle and serving in a front-line trench. He who carelessly allows the needless consumption of electric energy is a slacker pure and simple and is working in the interests of the German forces and against his own countrymen and our Allies.

Another Good Fuel-Saving Bulletin

"FUEL Saving in Office Buildings and Stores," or Bulletin No. 2 of the Advisory Engineering Committee to the Massachusetts Fuel Administration, has just made its appearance, and will bear reading by isolated-plant and heating engineers generally. The practical way in which the committee is placing the principles of fuel saving in the hands of laymen deserves warm praise, and as we remarked in connection with the first bulletin issued a few weeks ago by these energetic Bay Staters, it is fine that the subject matter presented is also of interest to the technical man. Ordinarily the presentation of a subject like fuel saving in a style of both engineering and popular interest would seem to be about as difficult as driving a fast trotter and a plow horse in a pair. If anybody in Massachusetts can drive such a team without coming to grief it is Dr. Hollis, and with so many other associates on the fuel-saving "band wagon" who know the route with their eyes shut, nothing but success is to be anticipated.

The new bulletin speaks for itself and need not be reviewed in these columns; but we cannot forbear calling the attention of the reader who gets one from Room 365, State House, Boston, to the marked family resemblance it bears to the first publication of the committee. Some of the material relative to firing boilers belongs equally well in both bulletins, and the committee showed its good sense in including some of its first "copy" in the second installment. As in the first bulletin, however, the reader cannot but be surprised at the many and often unsuspected sources of heat loss and fuel waste pertaining to every type of plant. Worn thresholds, for instance, are helping the Kaiser's cause through their inability to keep in the heat; and a failure to shut off steam on the sunny side of an office building earlier than on the shady side is another omission of patriotic importance. As in the first bulletin, perhaps the best thing about No. 2 is an organization chart for the establishment and then the continued regular work of a fuel-saving committee for typical establishments, showing the part the agent or superintendent, the engineer, the janitor, the tenants' representative or the department head (as in a store) can play in the battle against fuel waste. "Another good job well done" will be the verdict of every economy-seeking reader of this interesting and valuable publication.

Better Firemen

A FIREMAN feeds ten tons of coal to a hand-fired furnace in the course of a day's work.

At four dollars per ton this is twelve thousand dollars worth of coal per year of three hundred working days.

A good fireman can get through on twenty per cent. less than a poor fireman. This means that under the conditions cited a good fireman would save twenty-four hundred dollars' worth of coal a year.

In most cases firemen work more than three hundred days a year, shovel more than ten tons per day and their pay is around half of the above-computed saving.

In what other process would a manufacturer put twelve thousand dollars' worth of material into the hands of a common laborer as is so often done in power plants, to apply wastefully or usefully, as he wills or can?

One of the most immediately available ways to conserve coal is to improve fireroom methods. A good man at a little more money per week will save a lot more than his increased cost by the use of brains, simple tools and common material and will conserve coal without drawing upon our limited man power for new apparatus.

Garabed

Washington, Aug. 20.—A resolution to repeal the special patent granted by Congress last year for the perfection of the "Garabed free energy engine" has been introduced in the House. Representative Moore, of Pennsylvania, who introduced the resolution, said that since the committee of scientists had officially pronounced the Garabed claims to be of no value, stock jobbers were attempting to get hold of the patents to exploit the public.

Congress never granted any patent to Giragossian. It simply agreed to protect him in the use of "Garabed" if he could prove to the satisfaction of a committee that it was any good.

He couldn't.

Examination of the costs of coal mining by the United States Fuel Administration has been completed, and the Government is now presumably in a position to know how much it costs each producer to win the coal that he ships. Now fix the price to him at that cost plus a fair profit, pool the output and make the price to the consumer such as will pay a reasonable profit on the cost of mining and distribution. Nobody expects producers or handlers to function at a loss—and there is a rather resentful impression that they have not.

If ever Rhode Island coal is going to be burned, it ought to be right now. It is right there in New England, and all sorts of handicaps and difficulties are experienced in getting other coal in. We understand, however, that the mines are being dismantled and the machinery junked.

The man who has his power-plant records is at an advantage today.

CORRESPONDENCE

How One Plant Was Improved

It might be of interest to engineers to know how one plant was so improved that during last month the coal bill was $200 less than it had been before, notwithstanding about 10 per cent. increase in load over that carried during the last year. The main reason for this saving is due to the fact that the design of the boiler furnaces was changed last year. In doing this the boilers were raised so that they were 56 in. above the grate and enough of the bottom of the combustion chamber was taken out so the distance between it and the boiler was six feet.

In order to improve the combustion, a forced-draft fan was put in and so arranged that the suction came through the breeching so as to heat the air going to the ashpit. After these changes were made, we were able to burn the cheapest and poorest quality coal that could be bought in Minneapolis and that without smoke and with less waste than formerly. For example, if we had had to buy the same quantity and quality of coal during November of last year as we bought for the same month in 1916, it would have cost $1125.35, but at the price we paid the cost was $374.50, a difference of $750.85. As the other months of the year showed about the same saving, it is easily seen that it paid to alter and repair the furnaces.

It may be assumed that it was an easy matter in the first place to get these changes made, but as a matter of fact the owner absolutely refused to do it as the chief who put in the plant was an expert according to the owner's way of thinking. The chief originally was captain of the owner's motor boat and was advanced to chief engineer of the power plant at one jump. The engineer who followed him started firing for this captain-engineer, it being the first plant he ever worked in, but he advanced to chief engineer in less time than it takes to think about it.

When I asked the boss how long it had been since the engines had been indicated, he wanted to know what I meant. When I told him an indicator was to show how steam was being distributed in the engine cylinder, he said that he had never had any use for any such thing and he didn't see why he should get one now.

I was fortunate enough to own an indicator, and when it was used I found the engines in pretty bad shape as to the valve setting. In fact, when the valves were properly adjusted it worked very quietly and one can imagine my surprise when I noticed the boss perched up on the balcony over the engine room for four solid hours without moving or saying a word, looking at the engine. Finally, he came down to the engine room and said that he wanted to compliment me on the way the engine was running and was going to give me $10 a month more than I had been getting. Naturally, he wanted to know how I did it, and when I told him that my indicator was responsible for showing me what was needed, he was certainly surprised.

When I told him we were losing steam through the steam chest cocks, he said they were all right, but when I took them out he could see daylight through them. Going a little further, I told him that the ice machine should be overhauled, but he did not think so. I got after it that night and found that there was a $\frac{3}{8}$-in. clearance on the head end and that two of the four bolts were out of one crank, all badly bent and lying in the crank case, and there were no cotter pins in any of the other bolts.

It cost $200 to get the elevators properly repaired, and the steam and water piping in the plant was the worst I ever saw. For instance, in one place there was a steam pipe running from a machine to the sewer instead of into a steam trap. The drain of the water jackets for the ice machine went from $\frac{3}{4}$ in. to $\frac{1}{2}$ in., up to 1 in. and then back to $\frac{1}{2}$ in. The exhaust steam line to the hot-water heater was reduced from 2 in. to $1\frac{1}{4}$ in. and then back to 2 in. The return line from the heating system had two $1\frac{1}{4}$-in. pipes going into a 1-in. line and then back to a 2-in. near the vacuum pump. When we blew down the boiler, we had to pile sacks around the pipes to avoid being scalded. The boilers—well, one was run nine months without cleaning and one can imagine the rest.

When I wanted a hand CO_2 machine, my employer told me that he had no faith in it at all and that they were no good. I wanted one of those machines so badly that I ordered one from a salesman who came in a few days later, telling him that I would pay for it myself and then informed my employer of the fact. He was so mad that he sent his paper weights clear across the room and told me that he would not pay for it. I told him he didn't have to, as he could keep $10 a month out of my wages until it was paid for, and that if I couldn't convince him at the end of four or five months that it was a good investment I would be willing to go to that place where they don't shovel snow. When it arrived, I went after it and the fireman and soon had him averaging 11 per cent. CO_2, and at the end of the second month the boss gave me $25, saying that I needn't pay for the machine, and that he was going to give me another $5 increase per month.

This last exploit was the best thing I ever did, for ever since then I have had easy sailing, as the saying is, and now whenever I ask for apparatus or recommend changes, he tells me to go ahead, as I know best.

The hardest thing in a steam plant is for the chief to get the men to study. When I hire a man, I frankly tell him that I expect him to study and give him books, and if at the end of five or six days he has not learned anything, or does not ask any questions, I get rid of him, for it is useless to try to get efficiency with men who won't study as well as work. It is surprising how much one can learn himself in his attempts to help others.

The reason I started this educational propaganda is that about a year ago I put an advertisement in one of

the daily papers for an assistant engineer and I was disgusted with the men who answered it. One young fellow, who claimed to have had six years' experience in a central station of about 5000-kw. capacity, walked several times around the machines that were running, and when I asked him if we had direct- or alternating-current generators, he came back and said that he knew it was an alternating machine as he could tell it by the beat of the engine. Another fellow, about 40 years of age, told me I was using too much cylinder oil on the engine, but that it was all right as long as I caught it down there and used it again, and he pointed to a steam trap. Another wanted to know what steam pressure we carried. I said 100 lb. and he replied that I couldn't fool an old timer like him, because he could see it was 150 lb. and he pointed to the ammonia gage. Two men knew nothing about washing out boilers, three said that they would not go in a boiler to wash it, and four absolutely refused to even help wash out a boiler. Right then and there I made up my mind it was a case of work and study or get out, and I think I am right.

Baltimore, Md. J. F. WILKINSON.

Determining Power Output of Motors

The power consumed by a direct-current motor can be obtained by reading the volts and amperes taken by it, from meters connected in the circuit. The product of these values gives the watts consumed, which divided by one thousand gives the kilowatt consumption.

If the load is unsteady, the average of many readings is taken. The power delivered by a motor is less than its power consumption since the efficiency is always less than 100 per cent. owing to internal losses. We then have

$$\frac{Amperes \times volts}{1000} = kw.\ consumed$$

and

$$\frac{Amperes \times volts \times eff.}{746} = hp.\ delivered\ at\ pulley$$

With alternating-current motors another value must be included; that is, the power factor, which always has a value less than one. Its value is seldom steady for even a few minutes, as it changes with variations of load on the motor. The power factor is smallest when the motor is running light and greatest when running at full load. In the case of a single-phase motor we would have

$$\frac{Amperes \times volts \times power\ factor}{1000} = kw.\ consumed$$

and

$$\frac{Amperes \times volts \times p.f. \times eff.}{746} = hp.\ delivered\ at\ pulley$$

For a three-phase motor the corresponding formulas would be

$$\frac{\sqrt{3} \times amperes \times volts \times p.f.}{1000} = kw.\ consumed$$

and

$$\frac{\sqrt{3} \times amperes \times volts \times p.f. \times eff.}{746} = hp.\ delivered\ at\ pulley$$

Since in alternating-current volts times amperes does not give the watts consumed and the power factor cannot be determined from those readings alone, it is necessary to use an indicating wattmeter to determine the amount of power. The reading of the wattmeter is equal to volts × amperes × power factor, and hence the power factor can be found if the watts, volts and amperes are known; that is,

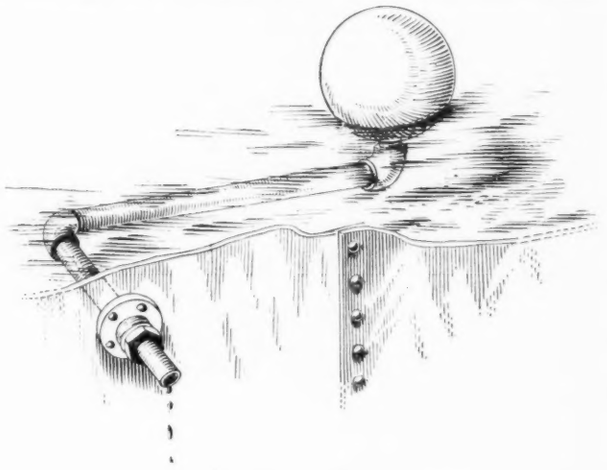
$$P.f. = \frac{watts}{volts \times amperes}$$

In the case of a three-phase motor two wattmeters are required and the total power is the sum of the two readings. HOWARD S. RICH.

Cromwell, Conn.

Some Float Pointers

As an improvement on the plan suggested by M. A. Saller, in the issue of July 23, page 136, for indicating a leaking float, I would suggest that the float be connected with the stem downward, making a stronger connection, and that the outlet should be slightly lower than the water level to secure perfect drainage.



FLOAT IN POSITION TO DRAIN

R. MCLAREN.

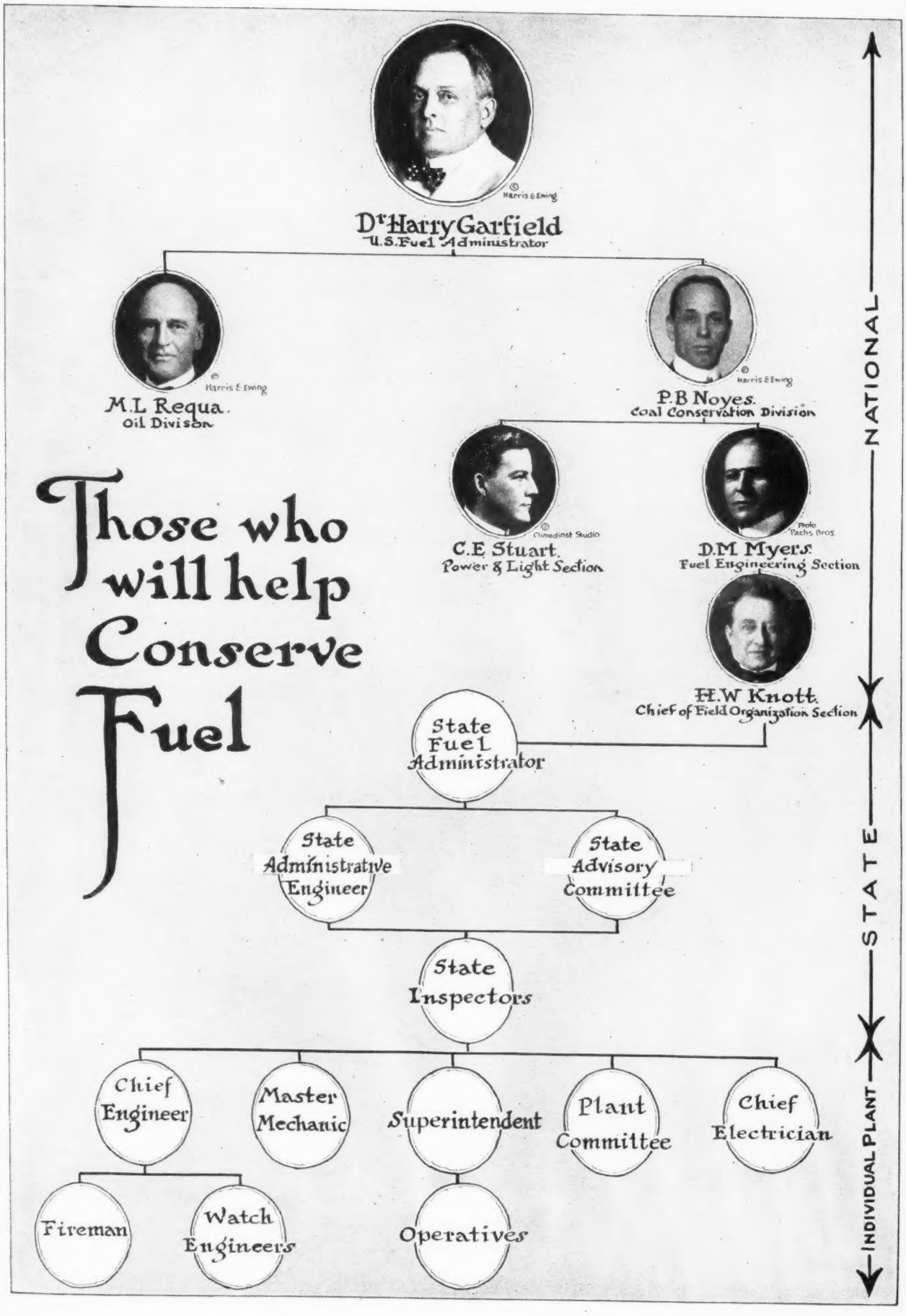
St. Catharines, Ont., Canada.

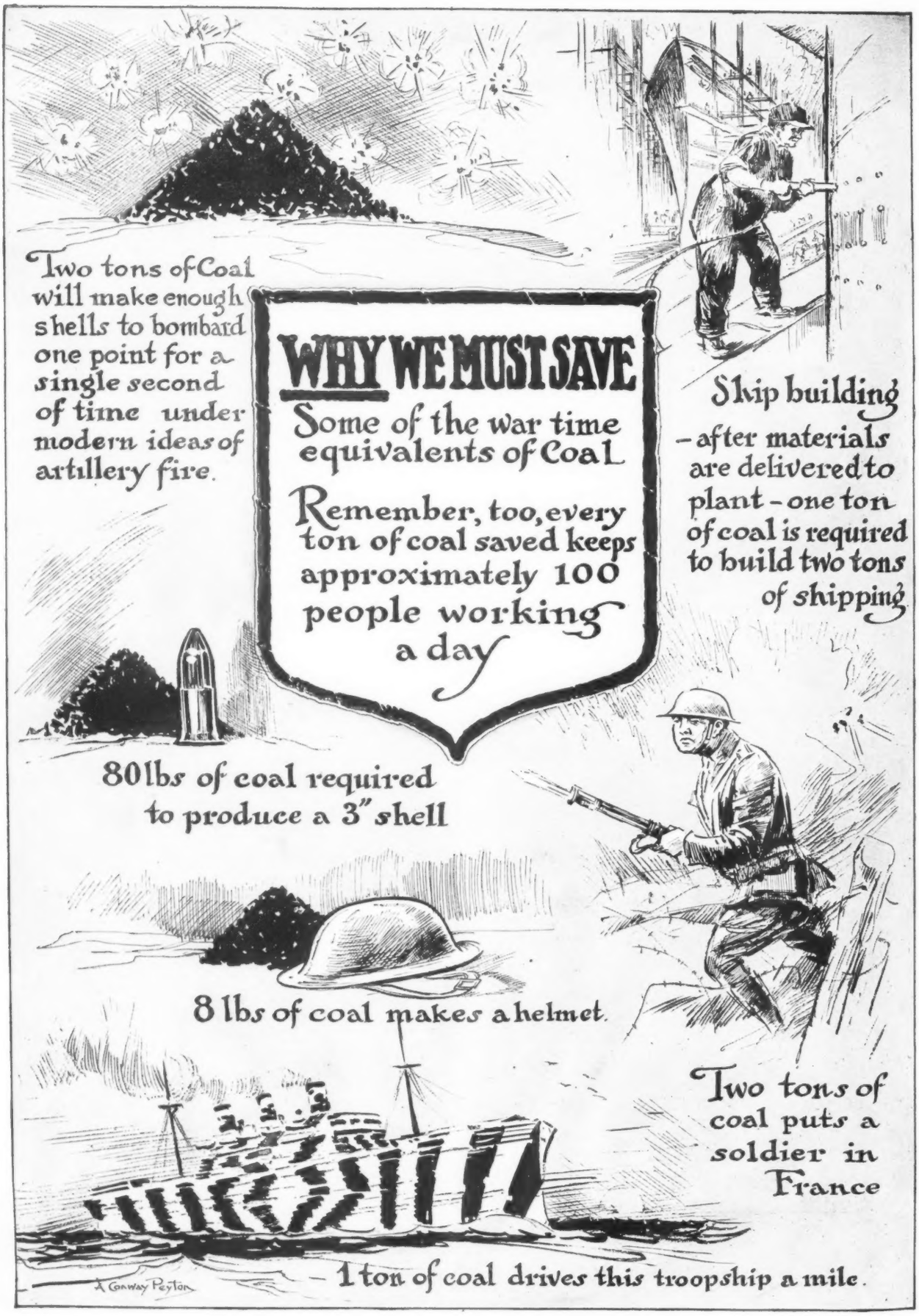
Staying Cylindrical Furnaces

The method described by Mr. Gauss in his article in *Power*, July 30, does not conform to the A. S. M. E. Boiler Code. The illustrative example given was for a furnace 36 in. in diameter, 36 in. high, plate thickness $\frac{5}{16}$ in., and a pressure of 125 lb. per sq.in. By formula *A*, Par. 239 of the Code, the steam pressure allowed on this furnace without stays would be 81 lb. per square inch.

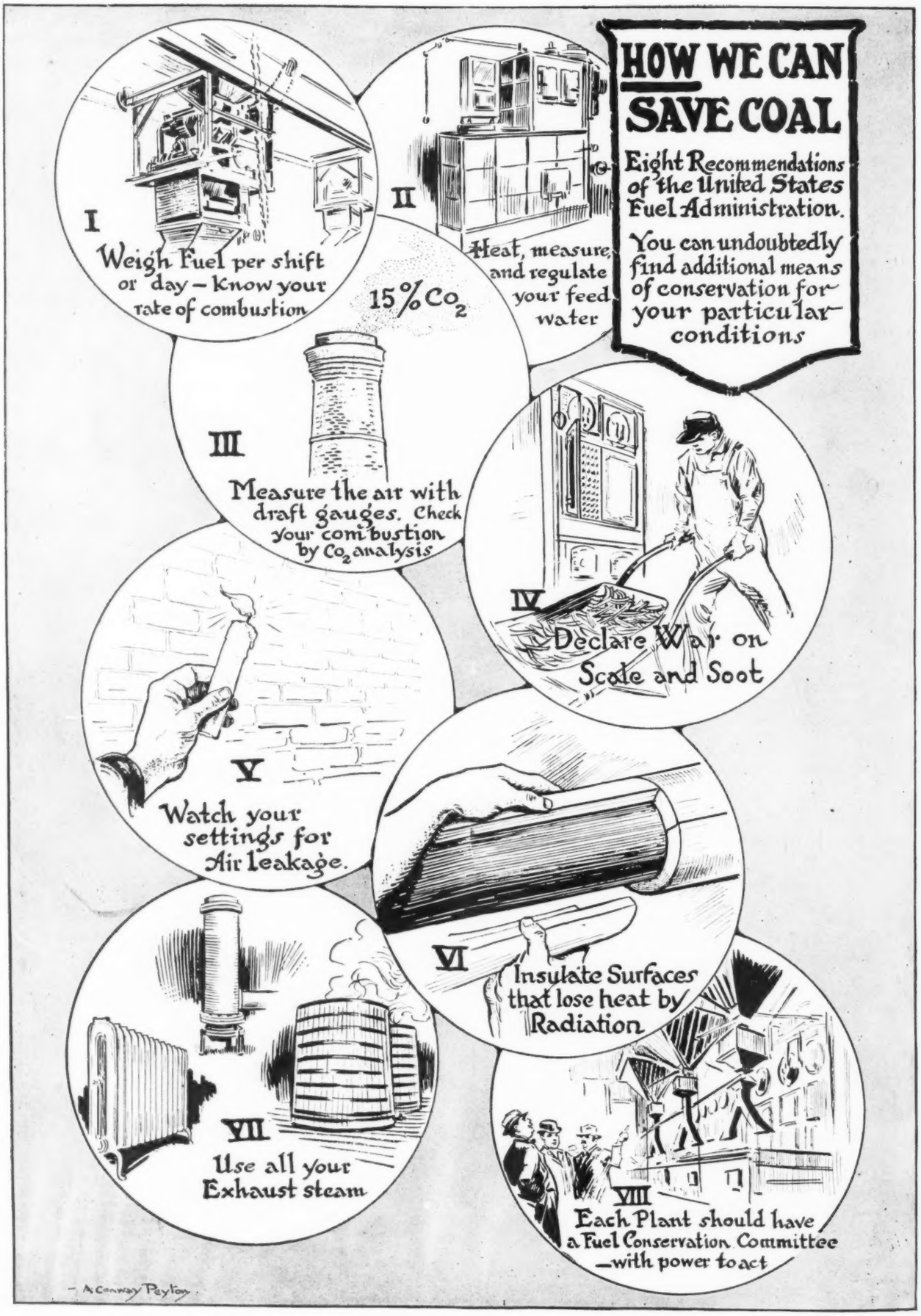
When computing the size and number of stays, credit was given for the strength that would support 81 lb.; that is, the difference between 125 lb. and 81 lb., or 44 lb., was taken as the pressure for which the furnace should be stayed. Although a great many people believe this to be the proper method, it does not conform to the Code; for Par. 212 says: "An internal cylindrical furnace which requires staying shall be stayed as a flat surface as indicated in Table 3." According to Table 3 of the Code referred to, it would be necessary to confine the pitch of stays to $4\frac{3}{4}$ in. instead of 7 in., as given in the article. J. H. FLAHERTY.

Olean, N. Y.


Those who will help Conserve Fuel
Dr Harry Garfield
U.S. Fuel Administrator
M.L. Requa.
Oil Division
P.B Noyes.
Coal Conservation Division
C.E Stuart.
Power & Light Section
D.M Myers.
Fuel Engineering Section
H.W Knott.
Chief of Field Organization Section
State Fuel Administrator
State Administrative Engineer
State Advisory Committee
State Inspectors
Chief Engineer
Master Mechanic
Superintendent
Plant Committee
Chief Electrician
Fireman
Watch Engineers
Operatives
NATIONAL
STATE
INDIVIDUAL PLANT


Two tons of Coal will make enough shells to bombard one point for a single second of time under modern ideas of artillery fire.
WHY WE MUST SAVE
Some of the war time equivalents of Coal
Remember, too, every ton of coal saved keeps approximately 100 people working a day
Ship building – after materials are delivered to plant – one ton of coal is required to build two tons of shipping
80 lbs of coal required to produce a 3" shell
8 lbs of coal makes a helmet.
Two tons of coal puts a soldier in France
1 ton of coal drives this troopship a mile.
A Conway Peyton

50,000,000 TONS
Nearly 22 times the size of the Great Pyramid of Gizeh! The Pyramid represented by 50,000,000 tons of Coal has a base 2500 feet square and a height of 960 feet.
50,000,000 Tons
The Woolworth building is a pigmy beside this huge bin of Coal.
WHAT WE MUST SAVE
50,000,000 Tons
Some Interesting Comparative Sketches
Is it any wonder that each Plant must get the most from every pound of Coal
10,000,000 Five-ton Motor Trucks would be required to carry this coal. Running night and day 50 feet apart at 20 miles an hour, they would take 6 months to pass a given point.
50,000,000 tons of Coal piled loose would fill nearly 2/3 of the Culebra Cut of the Panama Canal.
Equal to approximately 75 times the yardage of the Kensico Dam — one of the world's largest jobs in concrete.
A train of standard 50 ton cars to hold this coal would be approximately 8800 miles long. 14,300 locomotives would be required to pull it.
A Conway Peyton


HOW WE CAN SAVE COAL
Eight Recommendations of the United States Fuel Administration.
You can undoubtedly find additional means of conservation for your particular conditions
I
Weigh Fuel per shift or day – know your rate of combustion
II
Heat, measure, and regulate your feed water
15% CO_2
III
Measure the air with draft gauges. Check your combustion by CO_2 analysis
IV
Declare War on Scale and Soot
V
Watch your settings for Air leakage.
VI
Insulate Surfaces that lose heat by Radiation
VII
Use all your Exhaust steam
VIII
Each Plant should have a Fuel Conservation Committee –with power to act
A Conway Peyton

INQUIRIES OF GENERAL INTEREST

Obtaining Increase of Speed with Shaft Governor—How would the speed of a shaft-governor engine be increased? G. E.

The speed will be increased by increasing the resistance that the governor springs exert in opposing movement of the weights from centrifugal force, or by decreasing the weights, or by moving the weights nearer to the center of rotation. In adjusting most shaft governors, when the proper sensitiveness has been reached the change should be made in the weights alone.

Approximate Formula for Total Heat of Steam—What is the formula for obtaining the total heat of a pound of dry saturated steam, knowing the temperature? R. L.

The total heat of steam, or number of B.t.u. required to raise a pound of water at 32 deg. F. to a given temperature and convert it all into dry saturated steam at that temperature, may be approximately calculated for a temperature t of the Fahrenheit scale by the formula,

$$Total\ heat = 1086 + 0.305t.$$

On account of the variation of the specific heat and heat transformed into work in raising the water to different temperatures and converting it into steam at corresponding pressures, a simple and precise equation that will cover all temperatures cannot be formulated. For application to ordinary temperatures of steam in rough calculations, the formula quoted may be considered sufficiently accurate, but for close computations the total heat values employed should be obtained by consulting standard tables of the properties of steam.

Maximum Allowable Working Pressure for Cylindrical Boiler Shell—With a factor of safety of 6, what would be the highest allowable working pressure for a cylindrical boiler shell 72 in. in diameter, made of ½-in. steel plate of 55,000-lb. tensile strength and 85 per cent. efficiency of longitudinal joint? E. E.

The formula for determining the maximum allowable working pressure for a cylindrical shell is

$$P = \frac{TS \times t \times E}{R \times FS}$$

in which

P = Maximum allowable working pressure, lb. per sq.in.
TS = Tensile strength of shell plates, lb. per sq.in. of cross-sectional area.
t = Minimum thickness of shell plates, in inches.
E = Efficiency of longitudinal joint.
R = Radius = one-half the inside diameter of the outside course of the shell, in inches.
FS = The lowest factor of safety allowed.

Substituting the given values, the formula gives

$$P = \frac{55{,}000 \times 0.5 \times 0.85}{36 \times 6} = 108.2\ lb.\ per\ sq.in.$$

maximum allowable working pressure.

Piston-Travel Clearance and Cylinder Clearance—Neglecting the volume of the ports, what would be the per cent. of clearance of an engine of 36-in. stroke if there is ⅛-in. piston clearance at each end of the stroke? W. G. B.

Cylinder clearance is the volume of space in the end of the cylinder and connected steam spaces and passages, from the piston to the valve seats, when the piston is at the end of its stroke. A piston-travel clearance of ⅛ in. would be the distance the piston could be moved beyond the end of the stroke before it would strike the head of the cylinder. The percentage of piston displacement required by the space necessary for piston-travel clearance would not be the same as the percentage of cylinder clearance space neglecting the volume of the port passages or neglecting also the cylinder counterbore and other waste spaces, unless the end of the piston and inside of the cylinder head were of such shapes that if brought together their surfaces would exactly conform one to the other. Under such conditions the percentage of cylinder clearance for an engine of 36-in. stroke and ⅛-in. piston-travel clearance would be ⅛ × 100 ÷ 36 = about ½ of 1 per cent. This would be only about one-tenth the usual percentage of cylinder clearance when the volume of port passages and waste spaces as well as space for piston-travel clearance are properly included.

Indicated Horsepower Required for Pump—A direct-acting steam pump with 3-in. diameter and 10-in. stroke of water piston, working with a suction lift of 14 ft. against a head of 86 ft., makes 40 double strokes per minute, at which speed there is 3 lb. per sq.in. loss of water pressure from pipe friction. If the pump slippage is 5 per cent. and mechanical efficiency 60 per cent., what number of indicated horsepower must be developed by the steam end of the pump? C. W.

The total lift would be equivalent to a head of 86 + 14 = 100 ft. or 100 × 0.433 = 43.3 lb. per sq.in. and with 3 lb. per sq.in. loss of pressure from pipe friction would be equivalent to pumpage against a total pressure of 43.3 + 3 = 46.3 lb. per sq.in. with 0 suction lift. The area of the 3-in.-diameter pump piston being 3 × 3 × 0.7854 = 7.0686 sq.in., with 10-in. stroke, 40 double strokes per minute and 5 per cent. slippage, the useful work would be performed at the rate of

$$\frac{46.3 \times 10 \times 7.0686 \times 40 \times 2 \times (1 - 0.05)}{12 \times 33{,}000} = 0.628\ water\ hp.$$

and with 60 per cent. mechanical efficiency the steam end of the pump would be required to develop 0.628 ÷ 0.60 = 1.04 i.hp.

Maximum Allowable Working Pressure for Dome Head—What would be the allowable working pressure for a ½-in. steel dished head of a steam dome of 55,000 lb. TS, with pressure on the concave side, dished to a radius of 40 in., with flanged manhole opening turned inward to a minimum depth of 1¾ in.? J. S. V.

A formula that is generally approved for thickness of unstayed dished heads with the pressure on the concave side is

$$t = \frac{5.5 \times P \times L}{2 \times TS} + \tfrac{1}{4}$$

where

t = Thickness of plate, in.
P = Maximum allowable working pressure, lb. per sq.in.
TS = Tensile strength of the material, lb. per sq. in.
L = Radius to which the head is dished, in.

When a dished head has a manhole opening the thickness found by the formula is to be increased by at least ¼ in. over that called for by the formula, and with this allowance the formula becomes

$$t = \frac{5.5 \times P \times L}{2 \times TS} + \tfrac{1}{4}$$

from which

$$P = \frac{(4t - 1)\ TS}{11L}$$

Substituting the given values of t, TS and L, the maximum allowable working pressure would be

$$P = \frac{[(4 \times \tfrac{1}{2}) - 1]\ 55{,}000}{11 \times 40} = 125\ lb.\ per\ sq.in.$$

America's Energy Supply*

BY CHARLES P. STEINMETZ
Chief Consulting Engineer, General Electric Company

THE only two sources of energy that are so plentiful as to come into consideration in supplying our modern industrial civilization are coal—including oil, natural gas, etc.—and water power.

While it would be difficult to estimate the coal consumption directly, it is given fairly closely by the coal production. Since 1870 the average production can well be represented by a straight line, which represents an annual increase of 6.35 per cent., and gives 867 million tons as this year's estimated coal consumption. As it is difficult to get a conception of such an enormous amount, a comparison may illustrate it best. Using the coal produced in one year as building material, we could with it build a wall like the Chinese wall, all around the United States, following the Canadian and Mexican frontiers, the Atlantic, Gulf and Pacific coasts.

Estimating the chemical energy of the average coal as a little above 7000 calories, the chemical energy of one ton of coal equals approximately the electrical energy of one kilowatt-year (24-hour service). That is, one ton of coal is approximately equal in potential energy to one kilowatt-year.

Thus, the annual consumption of 867 million tons of coal represents in energy 867 million kilowatt-years.

However, as the average efficiency of conversion of the chemical energy of fuel into electrical energy is probably about 10 per cent., the coal production would be able, if converted into electrical energy, to give about 87 million kilowatts.

Assuming, however, that only one-half of the coal is used for power, at 10 per cent. efficiency, the other half as fuel, for metallurgical work, etc., at efficiencies varying from 10 to 80 per cent., with an average efficiency of 40 per cent., we get in electrical measure 217 million kilowatts (24-hour service) as the total utilized energy of our present annual coal production of 867 million tons.

The total rainfall of the North American continent between 30 and 50 deg. latitude represents 950 million kilowatt-years (24-hour service). That is, the total potential water power of the United States, or the hydraulic energy of the total rainfall, from the elevations where it fell, down to sea level, gives about 1000 million kilowatts. However, this is not available, as it would leave no water for agriculture; and even if the entire country were one hydraulic development, there would be losses by seepage and evaporation.

POWER AVAILABLE FROM THE RAINFALL

An approximate estimate of the maximum potential power of the rainfall, after a minimum allowance for agriculture and for losses, gives a total available potential energy of 380 million kilowatts (24-hour service).

Assuming now an efficiency of 60 per cent. from the stream to the distribution centers, there remain 230 million kilowatts (24-hour service) as the maximum possible hydro-electric power which could be produced if, during all seasons, every river, stream, brook or little creek throughout its entire length from the spring to the ocean, together with all the waters of the freshets, could be and were used. It would mean that there would be no running water in this country; in fact, there would be only stagnant pools connected by pipe lines to turbines exhausting into the next lower pool. Obviously, we could never reasonably hope to develop more than a part of this power.

It is interesting to note that the maximum possible hydraulic energy of 230 million kilowatts is little more than the total energy which we now produce from coal, and is about equal to the present total energy consumption of the country including all forms of energy. This is rather startling. It means that the hope that when coal once begins to fail we may use the water powers of the country as source of energy is and must remain a dream; for if today all the potential water power of the country were developed and every rain drop used it would not supply our present energy demand. Thus hydraulic power may and should supplement coal as a source of power, but can never replace it. This probably is the strongest argument for efforts to increase the efficiency of our means of using coal.

THE MODERN SYNCHRONOUS GENERATING STATION

In developing the country's water powers, thus far only those of greatest energy concentration have been considered; that is, those where a large volume and a considerable head of water were available within a short distance. This led, as the best solution for the problem, to the present type of hydro-electric generating station. The auxiliary and controlling devices in these stations have become so numerous as to make the station a complex structure requiring high operating skill and involving high cost of installation. Not only are all these devices necessary for the safe operation of the station, but at the same time it must be expected that, with the further increase of power of our electric systems, additional devices will become necessary for safe and reliable operation.

With this type of station it obviously is not possible, in most cases, to develop water powers of small and moderate size, and a generating station of a thousand horsepower will rarely, or one of a hundred horsepower hardly ever, be economical. On the other hand, a hundred-horsepower motor installation is a good economical proposition, and the average size of all the motor installations is probably materially below one hundred horsepower.

Only a small part of the country's hydraulic energy is found so concentrated locally as to make its development economically feasible with the present type of generating station. Therefore some different and very much simpler type of generating station must be evolved before we can attempt to economically develop these many thousands of small hydraulic powers, and collect the power of the mountain streams and creeks.

The following discussion of the simplification of the hydro-electric station to adapt it to the utilization of smaller powers is limited to the case where smaller hydraulic stations feed into a system containing some large hydraulic or steam-turbine stations from which the system may be controlled.

We may eliminate the low-tension busbars, with generator circuit-breakers and transformer low-tension circuit-breakers, and connect each generator directly to its corresponding transformer, making one unit of generator and transformer, and do the switching on high-tension busbars which, with the circuit-breakers, can be located outdoors. While it is dangerous to transformers to perform the switching on the high-tension side, due to the possibility of cumulative oscillations, this danger is reduced by the permanent connection of the transformer to the generator circuit, and is less with the smaller units used in small power stations, and therefore permissible in this case. However, the simplification effected is pronounced, since ammeters, voltmeter and synchronizing devices with their transformers are still retained on the low-tension circuits.

With the adoption of the induction generator the entire exciter plant is eliminated, as the induction generator is excited by lagging currents received from synchronous machines, transmission lines, and cables existing in the system. Thus are dispensed with the exciters, exciter busses, ammeters, voltmeters, alternator field rheostats, etc.; in short, most of the auxiliaries of the present synchronous station become unnecessary. Thus, the solution of the problem of the economic development of smaller water powers is found in the adoption of the induction generator.

However, it must not be forgotten that the simplicity of the induction generator station results from the trans-

*Extracts from a paper presented at the convention of the A. I. E. E. at Atlantic City, June, 1918.

ference of all the functions of excitation, regulation, and control to the main synchronous stations of the system, and thus the induction generator stations are feasible only as adjuncts to at least one large synchronous station (hydraulic or steam turbine) in the system, but can never replace the present synchronous generator stations in their present field of application.

However, the value of the induction generator lies not so much in the reduction of the cost of the generating station as in the reduction of the cost of the hydraulic development, through making it possible to apply to the electric generator the same principle which has made the electric motor economically so successful. Collect the power electrically just as we distribute it electrically.

We do not, as in the days of the steam engine, convert the electric power into mechanical power at one place by one big motor and distribute it mechanically by belts and shafts; but we distribute the power electrically, by wires, and convert the electric power to mechanical power, wherever mechanical power is needed, by individual motors throughout mill and factory

Electrical Collection of Generated Power

In the same way we must convert the hydraulic, that is, the mechanical power, into electrical power by individual generators located along the streams or watercourses within the territory, wherever power is available, and then collect this power electrically by medium-voltage collecting lines and high-voltage transmission lines, and so eliminate most of the cost of the hydraulic development, to solve the problem of the economical utilization of the water powers.

Naturally, then, we would use induction generators in these small individual stations, just as we use induction motors in individual motor installations, but where large power is available, there is the field of the synchronous generator, where the induction generator is undesirable, just as the synchronous motor is preferable where large power is required—unless the synchronous motor is excluded by conditions of starting torque, etc.

At first, and for some time to come, we would not consider going down to sizes of induction generators anywhere near as small as are common in induction motors. However, throughout the country there are undoubtedly many millions of kilowatts available in water powers which can be collected by induction-generator stations from 50 hp. upward, and which at fair heads, would require no abnormal machine design (no very slow speed).

Consider the instance of a New England river with a descent in its upper course of about 1100 ft. of varying gradient within five miles; at three places where the gradient is steepest, by a few hundred feet of cast-iron pipe and a small dam of 20 to 30 ft. length and a few feet height (just enough to cover the pipe intake), an average head of 150 ft. can be secured, giving an average of 75 hp. each, or a total of 225 hp. or 170 kw. This would use somewhat less than half the total potential power. The development of the other half would be left to meet future demands for additional power.

The installation of an electric system with 170 kw. would hardly be worth while; but there are numerous other creeks throughout the territory from which to collect power and which within a few miles pass high-potential transmission lines, coming from big synchronous stations into which the power-collecting lines from the induction-generator stations could be tied and from which they could be controlled.

The same reason that led to the conclusion that in the (automatic) induction-generator station is to be found the solution of the problem of collecting the numerous small amounts of hydraulic energy, also applies to the problem of collecting the innumerable small quantities of mechanical or electrical energy, which are or can be made available wherever fuel is consumed for heating purposes. Of the hundred million tons of coal annually consumed for heating purposes, most is used as steam heat. Suppose, then, we generate the steam at high pressure and interpose between steam boiler and heating system some simple form of high-pressure steam turbine, directly connected to an induction generator, and tie the latter into the general electrical power-distribution system. Whenever the heating system is in operation, electric power is generated, we may say as a "byproduct," and fed into the electric system.

The only difference between such steam-turbine induction-generator stations, collecting the available fuel power scattered throughout the cities and towns, and the hydraulic induction-generator stations collecting the powers of the streams throughout the country is that in the steam-turbine plant an excess speed cutoff must be provided, as the free-running steam-turbine speed is usually not limited to less than double speed, as is the case with the hydraulic turbine. Otherwise, however, no speed governing is required. A further difference is that the greater simplicity and therefore lower investment of the steam turbine plant would permit going down to powers of a few kilowatts perhaps.

We realize that our present method of using our coal resources is terribly inefficient. We know that in the conversion of the chemical energy of coal into mechanical or electrical energy, we have to pass through heat energy and thereby submit to the excessively low efficiency of transformation from the low-grade heat energy to the high-grade electrical energy. We get at best 10 to 20 per cent. of the chemical energy of the coal as electrical energy; the remaining 80 to 90 per cent. we throw away as heat in the condensing water, or worse still, have to pay for getting rid of it. At the same time we burn many millions of tons of coal to produce heat energy, and by degrading the chemical energy into heat, waste the potential high-grade energy which those millions of tons of coal could supply us.

It is an economic crime to burn coal for mere heating without first taking out as much high-grade energy, mechanical or electrical, as is economically feasible. It is this feature, of using the available high-grade energy of the coal before using it for heating, which makes the isolated station successful, though it has every other feature against it. To a limited extent combined electric and central steam-heating plants have been installed, but their limitation is in the attempt to distribute heat energy, after producing it in bulk, from a central station. Here again we have the same rule; to do it efficiently, do it electrically. In the efficiency of distribution or its reverse, collection, no other form of energy can compete with electric energy, and the economic solution appears to be to burn the fuel wherever heating is required, but first take out its available high-grade energy, and collect it electrically.

Electricity as Byproduct of Heating Plant

Assume we use 200 million tons of coal per year for power, at an average total efficiency of 12 per cent., giving us 24 million kilowatts (referred to 24-hour service) and use 200 million tons of coal for heating purposes, wasting its potential power.

If, then, we could utilize the waste heat of the coal used for power generation, even if thereby the average total efficiency were reduced to 10 per cent., we would require only 240 million tons of coal for producing the power and would have left a heating equivalent of 216 million tons of coal, or more than required for heating. That is, the coal consumption would be reduced from 400 million to 240 million tons, a saving of 160 million tons annually.

Or, if from the 200 million tons of coal, which we degrade by burning for fuel, we could first abstract the available high-grade power, assuming even only 5 per cent. efficiency, this would give us 10 million kilowatts (24-hour rate), at an additional coal consumption of 10 million tons, while the production of the 10 million kilowatts now requires 100 million tons of coal, more or less, thus getting a saving of 90 million tons of coal; or putting it the other way, a gain of 9 million kilowatts—12 million horsepower 24-hour service, or 36 million horsepower for an 8-hour working day.

It is obvious that we never could completely accomplish this; but even if we recover only one-quarter, or even only one-tenth of this waste, it would be a vast increase in our national efficiency.

Thus the solution of the coal problem, that is, the more economic use of fuel energy, is not only the increase of the thermodynamic efficiency of the heat engine, in which a radical advance is limited by formidable difficulties, but is the recovery of the potential energy of all the fuel, by electric collection.

Government Control of Power Plants

A bill that would give the President authority to take over all the power plants of the United States, whether steam, electrical or hydraulic, and to control them for the duration of the war, was introduced in the House on Aug. 19 by Representative Sims of Tennessee. The bill has the indorsement of the President and the Secretary of War, as well as of the heads of the various boards having direction of war activities and conservation. It carries an initial appropriation of $200,000,000, a large part of which would be spent in the purchase and building of power plants at the mouths of coal mines. In this way much of the low-grade fuel that cannot be shipped to market would be made available for the generation of electric power, which would be distributed by transmission lines to factories and plants engaged in doing war work.

The war program of this country has been hampered for some time by the shortage of power, and the situation is described as rapidly becoming acute. At present there are four pressing needs, namely: Increased production of power available for war industries in shipyards; economy in the consumption of fuel; reduction in the railroad freight load, especially in the fuel load; increased production of metallurgical coke and ammoniacal liquor, all recovered from coal.

Accordingly, the bill provides "that the President may construct or acquire power plants and transmission lines, and incidental property necessary for the production of material and commodities essential to the national defense." He may either take over privately owned power plants or advance funds from the appropriation to assist in their private operation. The power to construct or acquire any power plant, transmission lines or incidental property will terminate at the end of the war, and the power to operate and maintain the plants shall continue only for such time as the President shall deem necessary for the public interest. Compensation when the plants are taken over is to be fixed by the President. In case of a dispute, 75 per cent. of the amount fixed by the President shall be paid, and the owner has the right to sue for the remainder.

To Stabilize Price of Petroleum

A plan has just been made effective through the coöperation of the National Petroleum War Service Committee and the United States Fuel Administration that is intended to result in stabilizing the price of crude petroleum to both large and small refiners and maintaining the flow of crude oil in its present channels. It is believed that the arrangement will prevent any radical change in consumers' prices of gasoline and other oil products.

The details are to be handled by committees on conciliation and coöperation of the various producing fields. Mark L. Requa, General Director of the Oil Division of the United States Fuel Administration, recently met the producers and refiners of the mid-continent field in meetings at Tulsa, Oklahoma, and Houston, Texas. As a result of his suggestions the producers and refiners named from their own members committees to adjust any local dispute which, in the event they were unable to settle, it was agreed would be referred to the National Petroleum War Service Committee. Should the National Committee be unable to adjust the dispute referred to it then appeal may be had to the Fuel Administration.

The Fuel Administration believes that by leaving the settlement of all questions as to premiums and diversion of crude oil to the voluntary agreement of the industry itself the harmonious relations between the various interests will be maintained. The Fuel Administration is also endeavoring to have established fair differentials for refiners and distributers.

According to reports, great damage was done recently by the partial destruction by fire of an ammunition factory of the General Electricity Co. at Plauen, Germany, presumably by spontaneous combustion of explosives. A large number of lives are reported to have been lost.

George William Dickie

George William Dickie, naval architect and marine engineer, associated with engineering and shipbuilding on the Pacific Coast for nearly fifty years, died suddenly at his home in Oakland, Calif., Aug. 17, 1918, at the age of 74 years. Mr. Dickie was a native of Arboath, Scotland, coming to the United States in 1869, in which year he went to San Francisco. In 1870 he erected a gas plant at North Beach for the newly organized Pacific Gas Co., which plant, owned by the Pacific Gas and Electric Co., is still in operation. Shortly afterward he designed the first successful triple-expansion engine built in the United States, and a few years later he designed the first Scotch marine boiler on the Pacific Coast.

From 1870 to 1885 Mr. Dickie was connected with the old Risdon Iron Works, first as draftsman and later rising to the position of consulting engineer and designer. He designed the machinery for deep mining operations for the famous Con. Virginia Mine, installed in 1880, including the deepest pumping apparatus in use up to that time and the air compressors. He also designed and installed the machinery for the first big Spreckels' sugar mill erected in the Hawaiian Islands. He became general manager of the Union Iron Works in 1883, a position he held until 1905, when the plant was purchased by the Schwab interests. During that period he designed many privately owned ships as well as a large number of Government vessels. The best known of these are the old battleships "Oregon," "Wisconsin" and "Ohio" and the cruiser "Olympia," which became Admiral Dewey's flagship.

Mr. Dickie retired from active work about four years ago, but, following this country's entry into the war, offered his services to the Government and at the time of his death held the position of resident inspector for the United States Shipping Board at the Moore shipbuilding plant in Oakland. He was a member of the Technical Society of the Pacific Coast, the American Society of Naval Architects and Marine Engineers and the American Society of Mechanical Engineers.

Developing The Liberty Motor

It is understood that the Liberty Motor has completed the process of evolution through which it has for months been passing, and that the final perfecting touches have produced remarkable results with respect to speed. The present horsepower is 454, or 50 per cent. more than it developed early in the spring.

A few months ago just as quantity production was about to be launched, the request came for more horsepower without increased weight. This was done, the weight being held around 800 lb. and the horsepower, after some experimenting, notched up from 300 to 454.

The number of changes which have been made in the original Liberty Motor and which are responsible for the increases in production totals approximately 2200. But now it is understood there is nothing in sight to delay the big automobile companies from reaching their estimated output. By mid-winter production should be on an enormous scale.

Miners Warned of Propaganda

The Anthracite Committee has sent out a warning against German propaganda said to be circulated among mine workers for the purpose of curtailing the output of coal. One story circulated was that all coal sales would be stopped after Sept. 1, and this was promptly nailed by A. C. Campbell, fuel administrator of Luzerne county, Pennsylvania, who declared it a lie made out of whole cloth. German agents are said to be circulating among the men, trying to stir up trouble between operators and employees, but thus far have met with no success. In spite of the fact that the regular working force among anthracite miners has fallen off some 33,000 since the outbreak of the war, the industry is getting out approximately 275,000 tons of coal daily.

School for Power-Plant Engineers

The third annual school of power-plant engineers conducted by the Wisconsin Civil Service Commission and Department of Engineering for the operating engineers in the service of the State of Wisconsin will be held at Madison Aug. 15 and 16, 1918. All who are directly interested in power-plant operation and efficiency are invited to attend all sessions.

The school is held to help all engineers and firemen in the service of Wisconsin to a higher degree of efficiency. It is expected that those who attend will take back much in suggestion and inspiration to the engineers and firemen who are unable to be present. The coal situation and the problems of meeting it will play a large part in this year's discussions.

Each delegate should keep an itemized account of all necessary expenses, including railroad fare, sleeping-car fare, if necessary, room at hotel, meals and street car and bus fare and get a receipt from the hotel clerk when paying for room. Delegates must advance the money for their expenses

Fuel Facts

The United States Fuel Administration has issued a 64-page pamphlet entitled "Fuel Facts," dated Aug. 1, 1918, in which it gives a large number of brief items relating to the fuel situation, coal production, coke statistics, oil output, and the relation of various industries and practices to the conservation of fuel. One of the most valuable features of the publication is a complete and revised list of the personnel of the Fuel Administration. Copies of the pamphlet may be obtained by applying to the Educational Bureau, United States Fuel Administration, Washington.

Personals

C. W. Cross has been appointed special representative of railroad sales for the Chicago Pneumatic Tool Co. and **L. C. Sprague** as district manager of sales for New York.

Harry Himelblau has been appointed assistant administrative engineer for Illinois, and will be located in the office of the administrative engineer at 120 West Adams St., Chicago.

Captain W. Gerald Hawes, president of the John Wilfert Co. and the Hawes Foundry and Equipment Co. has just been appointed to the chairmanship of the Shipping Board for Brooklyn.

Vance McCarty, for the last twelve years manager of the Pittsburgh branch of Edw. R. Ladew Co., Inc., has been appointed general sales manager of the company, with headquarters in the New York office, 54 Franklin St. His connection with the Ladew company covers a period of eighteen years.

Harry B. Joyce, who has been connected with the United Electric Light and Power Co. for several years as power engineer, has received a commission as captain in the Quartermaster's Corps., U. S. A. His experience in practically every phase of engineering connected with the electric lighting company's business and his special knowledge of refrigeration are responsible for his appointment.

Engineering Affairs

The New England Water Works Association will not hold its usual convention this year, but instead will hold a business meeting in Boston, Sept. 11 and 12, with headquarters at the Association rooms, 715 Tremont Temple, and the meeting in Chipman Hall, on the floor below. It will be a win-the-war meeting. Its papers and discussions will be devoted especially to conservation, fuel economy and problems resulting from the high cost of materials and labor.

Miscellaneous News

An Eight-Foot Flywheel on a newly installed generator in the electric-light plant at New Rockford, N. D., burst Aug. 10, demolishing the roof and one side of the engine room. Parts of the wheel were carried as far as two blocks by the force of the explosion, one piece weighing 500 lb. crashing through the roof of a store building at that distance. No personal injuries resulted, but a $3000 property loss was entailed.

Laundries Are To Be Provided in the principal camps and cantonments. The average cost of each will be $150,000. The expenditure of $5,754,990 for this purpose has been authorized. The work will be done by the Construction Division. Power to operate the laundries will be supplied by special power houses which will be erected at the same time. The buildings in each of the larger camps will cost $176,000, while $130,688 is provided for each of the smaller camps.

The Fuel Administration's committee on Plant Conservation for Westchester County, New York, has arranged an illustrated lecture on "Saving Coal in the Power Plant," by Charles H. Bromley, associate editor of "Power." The lecture will be given in the County Court House, White Plains, N. Y., 2 p. m. Tuesday, Sept. 18. Employers are coöperating by letting off as many of their men as can be spared, paying their transportation to White Plains and paying them for the time off.

A Steam-Electric Power Plant of 90,000 kw. capacity is to be constructed shortly at Philadelphia, to meet a possible shortage of power at Hog Island and other shipbuilding centers in that section of the country, as recently announced by Charles Piez, vice president of the Emergency Fleet Corporation. The estimated cost of the proposed plant is $11,000,000, and it is understood that the Philadelphia Electric Co. has offered to construct the power-producing facilities to supply the load if the financial support of the Government is granted.

Business Items

The Sarco Co., Inc., of New York, has opened a new office in the Healey Building, Atlanta, Ga., under the management of C. R. Dunwody.

The Largest Engine Order ever given is probably that placed by the United States Government with the McIntosh & Seymour Corp., of Auburn, N. Y., for 52 Diesel engines, the price being between $5,000,000 and $6,000,000.

The Chicago Pneumatic Tool Co. announces that work has been started on the erection of an up-to-date addition to its Cleveland plant, which is planned to double the present output. It is expected that the work will be completed on the building itself about Nov. 1.

The Dearborn Chemical Co. has just made general announcement of the inauguration of a specialties department for the manufacturing and marketing of a number of specialties of interest to manufacturers of steel products. One of the most important of these is a rust preventive, known as No-Ox-Id. The research department of the Dearborn laboratories has devoted some three or four years to the development and testing of these specialties.

New Construction

Proposed Work

Conn., Bridgeport—The Eastern Malleable Iron Co., South Ave., has awarded the constract for the construction of a 2-story, 30 x 50 ft. foundry on South Ave., to Schwartz Bros., 95 River St. Conveying apparatus will be installed in same. Estimated cost, $15,000.

Conn., Hazardville—Gordon Bros., Scitico St., Thompsonville, is having plans prepared by Ford, Buck & Sheldon, Inc., 60 Prospect St., Hartford, for the erection of a 2½-story, 22 x 52 ft. power house; equipment including boilers will be installed. Total estimated cost, $25,000.

Conn., New Haven—The Connecticut Sash & Door Co., 248 Park St., is in the market for electric motors, alternate current, conveying apparatus, etc., for installation in the proposed 1-story, 50 x 90 ft. planing mill on Grand Ave. Total cost, $15,000. R. W. Fabian, 147 Bradley Ave., Arch.

Conn., New London—The National Housing Co. will install a steam heating system in the proposed housing project. Plans include the erection of one hundred eighteen 2½-story houses, etc., on Jefferson and Lincoln Aves. Total cost, $500,000. L. L. Tribus, Engr.

Conn., Shelton—The Holmes Manufacturing Co. is in the market for electric motors and shafting for installation in the proposed 1-story, 50 x 100 ft. machine shop. Total estimated cost, $18,000. Sperry Eng. Co., 82 Church St., New Haven, Engr.

Conn., Stamford—The Universal Stamping Co., Walnut and Pacific St., is receiving bids for the erection of a 1-story, 40 x 150 ft. factory. A steam heating system will be installed in same. Estimated cost, $22,000.

N. Y., Buffalo—Armour & Co., 208 South La Salle St., Chicago, will install a steam heating system in the proposed 5 story, 127 x 128 ft. addition to its plant on Scott St. Total cost, $50,000. R. C. Clark, Chicago, Arch.

N. Y., East Aurora—Nales Dairy Products Co., c/o R. North, Arch., Niagara Life Bldg., is in the market for two 60 hp. boilers in connection with the proposed 2-story milk station and dairy produce building.

N. Y., Lyons Falls—The Moyer and Pratt Co. has awarded the contract for the construction of a 2-story, 100 x 105 ft. paper mill to L. W. Charlebois. Equipment including electric motors, pumps, belting and shafting, will be installed in same. Estimated cost, $50,000.

N. Y., Seneca Falls—The Seneca Falls Manufacturing Co. has awarded the contract for the construction of a 2-story, engine manufacturing plant to T. H. McHale and Sons, Cahill Bldg., Syracuse. Equipment including electric motors, shafting and belting will be installed in same. Estimated cost, $50,000.

W. Va., Charleston—The West Virginia Water & Electric Co., 131 Summers St., plans to extend its electric distribution and water systems. Estimated cost, $1,250,000. W. C. Davisson, Vice Pres.

Fla., Jacksonville—R. N. Ellis, Purchasing Agent, City Hall, will soon award the contract for furnishing and delivering f.o.b. Jacksonville, 600 kw. more or less of standard pole type transformers, complete, with hangers, primary voltage 2200, secondary voltage, 110,220, in varying sizes from 7½ to 50 kva., inclusive; 500 kw. more or less single phase oil cooled transformers of subway type, primary voltage 2200, secondary voltage 110,220, in varying sizes from 10-50 kva., with pipe union type castings for secondary leads; 600 induction recording wattmeters, both single and multiple phase, for 110 and 220 volts, 60 cycles and 7200 alternations.

Ohio, Akron—The Goodyear Tire and Rubber Co., Market St., has awarded the contract for the erection of a 1-story power plant on East Market St. A steam heating system and complete power equipment will be installed in same. Total estimated cost, $250,000.

Ohio, Akron—The Hippodrome Arcade Co., Akron Savings and Loan Bldg., will install a steam heating system in the proposed 2- and 3-story theatre and arcade on Water, Main and Center St. Total estimated cost, $350,000. S. H. Good, 511 Flatiron Bldg., Arch.

O., Akron—G. P. Hoffman, Dir. of Public Service, will receive bids until Sept. 12, for furnishing one 30 in. and one 36 in. 3 42 in. motor-driven gate valves and 3 10 in. automatic air valves.

Ohio, Cleveland—The J. P. Schweitzer Co., 8400 Madison Ave., is receiving bids for the installation of a steam heating system in the proposed 2-story, 40 x 123 ft. factory to be erected at 1983 West 85th St. Estimated cost, $25,000.

Ohio, Cleveland—Stearns Motor Sales Co., 2106 Euclid Ave., let contract for the erection of a 1-story, 134 x 150 ft. service station on 1969 E. 61st St., to A. W. Kilbourne Co., 505 Swetland Bldg. A steam heating system will be installed. Total cost, $50,000.

Ohio, Cleveland—Swift & Co., West 65th St., is receiving bids for the installation of a steam heating system in the proposed 1-story, 50 x 102 ft. machine shop to be erected at 3240 West 63rd St. Total cost, $25,000. C. K. Kane, Chicago, Arch.

Ohio, Lima—The East Iron & Machine Co., 352 East Market St., will install a steam heating system in the proposed 2-story, 200 x 600 ft. factory to be erected on East Market St.

O., Lorain—The Cleveland Macadam Co., 1040 Leader-News Bldg., plans to install air compressors, motors, etc., in its proposed shipyard. Total estimated cost, $500,000.

Ohio, Maumee—The Board of Education will install a hot air blast in the proposed 2-story, 60 x 185 ft. high school, here. Bates & Gamble, 601 E. H. Close Bldg., Toledo, Engr.

Ohio, Portsmouth—Schmidt, Garden and Martin, Engr., 104 South Michigan Ave., Chicago, will soon award the contract for the installation of a low pressure steam heating system in the proposed 3-story, 46 x 104 ft. hospital for H. A. Sherman.

Ohio, Springfield—The Superior Gas Engine Co., Sheridan Ave., will build two 1-story factory buildings, 60 x 160 ft. and 58 x 90 ft. A steam heating system will be installed in same. Total estimated cost, $40,000. T. A. Graham, supt.

Mich., Detroit—The Aluminum Castings Co., 6210 Carnegie Ave., Cleveland, Ohio, will install a steam heating system in the proposed 1- and 2-story factory. Estimated cost, $100,000. W. H. Williams, Engr.

Kan., Hope—Riddle & Riddle, Eng., Abilene, are in the market for a pump, tower, etc., for city water-work project. Estimated cost, $36,000.

Mo., Independence—First Christian congregation will install a hot water heating plant and ventilation system in the proposed 2-story, 100 x 100 ft. church on Pleasant and Kansas Aves. Equipment includes motors for fans, electric pumps, etc. Total cost, $100,000. J. H. Felt Co., Kansas City, Archt.

Mo., Kansas City—The Swenson Constr. Co. will receive bids for electrical and mechanical equipment to be installed in the new building for the Southwest Bell Telephone Co., 11th and Oak St., now under construction. Plans include an electric generator, electric wiring, switchboard, oil engine, etc.

Mo., St. Charles—The American Car & Foundry Co., Syndicate Bldg., St. Louis, will install a steam heating system in the proposed 1½ story, 96 x 246 ft. machine and pattern shop. Total cost, $50,000. Brussel & Viterbro, Wright Bldg., St. Louis, Engr.

Tex., Ft. Worth—J. Neimeyer, Camp Quartermaster, Camp Bowie received authorization from Washington, D. C., to improve the water-works system. Plans include 2 gas motor engines for pumping, etc.

Okla., Duncan—City plans an election soon to vote on a $30,000 bond issue for the erection of a lighting plant. The Benham Eng. Co., Colcord Bldg., Oklahoma City, Engr.

CONTRACTS AWARDED

Conn., Shelton—The Holmes Manufacturing Co. has awarded the contract for the construction of a power house, factory building, etc., on Caran Ave., to the Sperry Eng. Co., 82 Church St., New Haven. Total estimated cost, $30,000.

N. J., Trenton—City received low bids for the installation of one 25,000,000 gal. steam driven centrifugal pump and one 20,000,000 gal. electrical driven centrifugal pump, one generator, one motor with appurtenances, etc., from H. E. Stahl, 275 Bellevue Ave., $123,000; I. N. Beeler, City Bank Bldg., Syracuse, N. Y., $148,750. Noted June 4.

Wash., D. C.—The Bureau of Supplies and Accounts, Navy Dept., has awarded the contract for furnishing power presses to Ferracute Machine Co., East Commerce St., Bridgeton, N. J. Estimated cost, $1860.

D. C., Wash.—The Bureau of Supplies and Accounts, Navy Dept., has awarded the contract for furnishing 1 motor, to the Reliance Electrical & Engineering Co., Munsey Bldg.

D. C., Wash.—The Bureau of Supplies and Accounts, Navy Dept., Wash., D. C., has awarded the contract for furnishing motor generator sets, to Randle Manufacturing Co., Cincinnati, Ohio, $900.

D. C., Wash.—The Bureau of Supplies and Accounts, Navy Dept., received low bids furnishing one 400 kw. motor generator, from the General Electric Co., River Rd., Schenectady, N. Y., $10,800; Allis-Chalmers Manufacturing Co., Clinton St., Milwaukee, Wis., $11,960; Westinghouse Electric and Manufacturing Co., Hibbs Bldg., Wash., D. C., $12,150; Ridgway Dynamo Co., Ridgway, Penn., $12,568; Wireless Instrument Co., 47 West St., New York City, $13,399.

D. C., Wash.—The Bureau of Supplies and Accounts, Navy Dept., received bids for furnishing and delivering equipment as follows:

(Item 1) (a), 4 generating sets; Schedule No. 51291, Class 657, delivery Navy Yard, Brooklyn, N. Y., (b) 16 gasoline electric generating sets; Schedule No. 51313, Class 659, delivery Philadelphia, Penn., from Eli Bridge Co., Roodhouse, Ill., (a) $2544, (b) $2544; Buffalo Gas Motor Co., 1280 Niagara St., Buffalo, N. Y., (a) $1432, alternate $1454 and $1739; (b) $1432, alternate $1454 and $1739; Anderson Engine Co., 4036 North Rockwell St., Chicago, (a) $1805, (b) $1750; Mathews Engine Co., Monroe and King Sts., Sandusky, Ohio, (a) $1900, (b) $1900; Star Electric Motor Co., 640 Frelinghuysen Ave., Newark, N. J., (b) $1432.

Va., Richmond—The Virginia Baking Co., 200 South 11th St., has awarded the contract for the erection of a 41 x 75 ft. brick boiler house, oven, etc., to E. L. Bass and Bros., 708 Bainbridge St. Total estimated cost, $150,000.

Va., St. Julien's Creek—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., has awarded the contract for the erection of a power house to Johansen and Kiernan, City Bank Bldg., Norfolk. Estimated cost, $12,963. Noted July 30.

La., New Orleans—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., has awarded the contract for the installation of boilers and superheaters to Babcock & Wilcox, North American Bldg., Philadelphia, Penn. Estimated cost, $23,930. Noted July 23.

Ohio, Cleveland—The Cleveland Illuminating Co., Illuminating Bldg., will build a 1-story, 39 x 45 ft. brick, steel and rein.-con. addition to its power house at 720 East 70th St. Estimated cost, $10,000. W. J. Porter, Illuminating Bldg., Arch.

Ill., Chicago—The P. M. Eddy Foundry Co., 327 West Grand Ave., has awarded the contract for the erection of a 1-story, 90 x 284 ft. foundry at 1051 South Menard Ave., to the Austin Co., 122 South Michigan Ave. Estimated cost, $105,000. A high pressure steam heating system will be installed in same.

Ill., Quincey—The Adams Co. has awarded the contract for the installation of a low pressure steam heating system in the proposed 1- and 2-story, 35 x 75 ft. and 36 x 86 ft. tuberculosis canitarium to Best Bros., Quincey. Total estimated cost, $60,000.

Mo., Joplin—The Hittig Lead and Zinc Co., 328 Frisco Bldg., will rebuild its plant and install boilers, engines, air compressors, etc. Estimated cost, $70,000. R. M. Simrall, Supt.

Mo., Rich Hill—City has awarded contract for furnishing engine, generator, air compressors and motor, switchboard equipment, steam and exhaust piping, etc., to the Merkle Machinery Co., Interstate Bldg., Kansas City. Estimated cost, $10,600. Noted July 4.

Mo., St. Louis—D. O'Neill, 6481 Ellenwood Ave., has awarded the contract for the construction of a garage, and the installation of a heating plant and gasoline tank in same, to S. Abrahams Constr. Co., Chemical Bldg.

Okla., Okmulgee—The Board of Education has awarded the contract for the installation of a heating system in the proposed 2-story school to O'Connor Co., Muskogee. Total estimated cost, $55,000.

Calif., Oakland—The Emergency Fleet Corporation, Wash., D. C., has awarded the contract for the construction of 20 diesel engines, to the Skandia Pacific Oil Engine Co., Oakland. Estimated cost, $2,500,000.

H. T., Pearl Harbor—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., received an only bid for the erection of an extension to the power house here, from C. C. Moore and Co., Sheldon Bldg., San Francisco. Noted July 30.

THE COAL MARKET

Boston—Current quotations per gross ton f.o.b. mines are as follows:

ANTHRACITE

	Circular Current
Buckwheat	$3.40
Rice	2.90
Boiler	2.65
Barley	2.40

All-rail rate to Boston is $2.86.

BITUMINOUS

Bituminous, $8 to $8.75.

Pocahontas and New River, f.o.b. Boston, $8.35 to $8.90.

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports* are as follows:

	Circular	Individual
Pea	$5.20	$5.95
Buckwheat	5.15	5.90
Rice	4.65	5.10
Barley	4.15	4.30
Boiler	4.60	...
Broken	6.75	7.50
Egg	6.35	7.10
Stove	6.60	7.35
Chestnut	6.70	7.45

Quotations for domestic coals at the upper ports are 5c. higher on account of the difference in freight rates. Prices for buckwheat, rice, barley and boiler are not fixed by the Government.

BITUMINOUS

Current quotations, gross tons, based on Government prices at the mines, net ton; f.o.b. Tidewater, at the lower ports, are as follows:

	Mine Gross	F.O.B. N.Y. Gross
Central Pennsylvania (Mine run, Prepared or Slack)	$3.30	$5.45
Upper Potomac, Cumberland & Piedmont Fields:		
Run of Mine	3.08	5.23
Prepared	3.36	5.51
Slack	2.80	4.95

Quotations at the upper ports are 5c. higher on account of the difference in freight rates.

The foregoing prices ar exclusive of the 3 per cent. war freight tax on both anthracite and bituminous.

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The ratte to the upper ports is 5c. higher than to the lower ports.

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	Current	One Yr. Ago	Current	One Yr. Ago
Pea	$3.45	$3.10	$4.60	$4.00
Barley	2.40	1.90	3.30	2.15
Buckwheat	3.40	2.90	4.45	3.80
Rice	2.90	2.40	3.80	3.40
Boiler	2.70	2.20	3.70	3.30

Chicago—Steam coal prices f.o.b. mines:

	Illinois Coals	Southern Illinois	Northern Illinois
Prepared sizes		$2.55—2.70	$3.25—3.40
Mine-run		2.35—2.50	3.00—3.15
Screenings		2.05—2.20	2.75—2.90

St. Louis—Prices per net ton f.o.b. mines are as follows:

	Williamson and Franklin Counties	Mt. Olive & Staunton	Standard
6-in. lump	$2.55-2.70	$2.55-2.70	$2.40@2.70
2-in. lump	2.55-2.70	2.55-2.70	2.40@2.70
Steam egg	...	...	2.40@2.70
Mine-run	2.35-2.50	2.35-2.50	1.85@2.00
No. 1 nut	2.35-2.50	2.55-2.70	...
2-in. screen	2.05-2.20	2.05-2.20	...
No. 5 washed	2.05-2.20	2.05-2.20	1.25@1.50

Williamson-Franklin rate to St. Louis is $1.10, other rates, $0.95.

Birmingham—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared Sizes	Slack or Screenings
Big Seam	$2.50	$2.80	$2.20
Cahaba, Black Creek, Brookwood, Blue Creek	3.20	3.45	2.80
Pratt, Jaeger, Jefferson Nickel Plate	2.70	3.00	2.40
Corona	2.75	3.10	2.40

The above are Government prices per net ton of 2000 lb. mines and include the 45c. per ton allowed by the wage agreement, less 10c. reduction which was effective May 25, as a result of the agreement with the railroad administration for furnishing fuel coal.

PRICES—MATERIALS AND SUPPLIES

These are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

POWER-PLANT SUPPLIES

HOSE—

	Fire	50-Ft. Lengths
Underwriters' 2½-in.		80c. per ft.
Common, 2½-in.		25¢

	Air		
	First Grade	Second Grade	Third Grade
¾-in. per ft.	$0.65	$0.40	$0.30

Steam—Discounts from List

First grade..... 15¢ Second grade..... 25¢ Third grade..... 33⅓¢

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition..... 50¢ Best grade..... 30¢
Standard..... 40¢

Note—Above discounts apply on new list issued July 1.

LEATHER BELTING—Present discounts from list in the following cities are as follows:

	Medium Grade	Heavy Grade
New York	40+5%	35%
St. Louis	45%	40%
Chicago	45%	40%
Birmingham	35%	40%
Denver	35%	30%

RAWHIDE LACING—40%.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam	$0.99
Asbestos for high-pressure steam	1.76
Duck and rubber for piston packing	1.10
Flax, regular	.99
Flax, waterproofed	1.21
Compressed asbestos sheet	1.10
Wire insertion asbestos sheet	1.32
Rubber sheet	.66
Rubber sheet, wire insertion	.99
Rubber sheet, duck insertion	.55
Rubber sheet, cloth insertion	.25
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.21
Asbestos wick, ½- and 1-lb. balls	.75

PIPE AND BOILER COVERING—Below are discounts and part of standard lists:

PIPE COVERING

Pipe Size	Standard List Per Lin.Ft.
1-in.	$0.27
2-in.	.36
6-in.	.80
4-in.	.60
3-in.	.45
8-in.	1.10
10-in.	1.30

BLOCKS AND SHEETS

Thickness	Price per Sq.Ft.
½-in.	$0.27
1-in.	.30
1½-in.	.45
2-in.	.60
2½-in.	.75
3-in.	.90
3½-in.	1.05

85% magnesia high pressure ..... 5% off

For low-pressure heating and return lines: 4-ply..... 58% off; 3-ply..... 60% off; 2-ply..... 62% off

GREASES—Prices are as follows in the following cities in cents per pound for barrel lots:

	Cincinnati	Chicago	St. Louis	Birmingham	Denver
Cup	7	5¼	13	8½	12½
Fiber or sponge	8	6	13	8½	20
Transmission	7	6	13	9	20
Axle	4½	4	4.1	3¾	5½
Gear	4⅝	4½	7.0	8	9
Car journal	22 (gal.)	3½	4.3	5½	8½

COTTON WASTE—The following prices are in cents per pound:

	New York		Cleveland	Chicago
	Current	One Year Ago		
White	11.00 to 13.00	13.00	16.50	12.00 to 16.50
Colored mixed	8.50 to 12.00	12.00	13.00	11.50 to 14.00

WIPING CLOTHS—Jobbers' price per 1000 is as follows:

	13½ x 13½	13½ x 20½
Cleveland	$52.00	$58.00
Chicago	48.00	50.00

LINSEED OIL—These prices are per gallon:

	New York		Cleveland		Chicago	
	Current	One Year Ago	Current	One Year Ago	Current	One Year Ago
Raw per barrel	$1.90	$1.16	$2.00	$1.20	$1.97	$1.21
5-gal. cans	2.00	1.26	2.15	1.35	2.17	1.36

WHITE AND RED LEAD in 500-lb. lots sell as follows in cents per pound:

	Red				White	
	Current		1 Year Ago		Current	1 Yr. Ago
	Dry	In Oil	Dry	In Oil	Dry and In Oil	Dry and In Oil
100-lb. keg	14.00	14.50	13.25	13.50	14.00	13.00
25- and 50-lb. kegs	14.25	14.75	13.50	13.75	14.25	13.25
12½-lb. keg	14.50	15.00	13.75	14.00	14.50	13.50
5-lb. cans	.....	.....	15.25	15.50	16.00	15.50
1-lb. cans	.....	.....	.....	.....	17.00	.....

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel ⅞ and smaller	30¢	45-5%	45¢
Tinned	30¢	45-5¢	45¢

Button heads, ¾, ⅞, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.:

New York...$5.65 Cleveland...$5.15 Chicago...$5.67 Pittsburgh...4.65

Coneheads, same sizes:

New York...$5.75 Cleveland...$5.25 Chicago...$5.77 Pittsburgh...$4.75

REFRACTORIES—Following prices are f. o. b. works, Pittsburgh:

Chrome brick	net ton	$175.00
Chrome cement	net ton	75.00
Clay brick, 1st quality fireclay	per 1000	50.00–55.00
Clay brick, 2nd quality	per 1000	35.00–40.00
Magnesite, raw	per ton	30.00–35.00
Magnesite, calcined	per ton	32.00–35.00
Magnesite, dead burned	net ton	32.00–35.00
Magnesite brick, 9 x 4½ x 2½ in.	net ton	110.00–125.00
Silica brick	per 1000	50.00–60.00

Standard size fire brick, 9 x 4½ x 2½ in. The second quality is $4 to $5 cheaper per 1000.

St. Louis—High grade, $55; St. Louis grade, $40.
Birmingham—Fire clay, $55-60; silica, $55-60.
Chicago—Second quality, $25 per ton.
Denver—Silica, $35 per 1000.

BABBITT METAL—Warehouse prices in cents per pound:

	New York		Cleveland		Chicago	
	Current	One Year Ago	Current	One Year Ago	Current	One Year Ago
Best grade	125.00	70.00	103.00	73.00	100.00	70.00
Commercial	70.00	40.00	23.00	22.00	24.00	25.00

SWEDISH (NORWAY) IRON—The average price per 100 lb., in ton lots, is:

	Current	One Year Ago
New York	$16–19	$14.00
Cleveland	20.00	13.30
Chicago	19.00	12.50

In coils an advance of 50c. usually is charged.
Note—Stock very scarce generally.

POLES—Prices on Western red cedar poles:

	New York	Chicago	Denver	San Francisco
6 in. by 30 ft.	$5.82	$5.17	$4.55	$5.17
7 in. by 30 ft.	7.65	6.85	6.10	6.85
7 in. by 35 ft.	11.10	10.00	8.95	10.00
8 in. by 35 ft.	12.65	11.35	10.10	11.35
7 in. by 40 ft.	12.85	11.50	10.20	11.50
8 in. by 45 ft.	18.90	16.90	15.00	16.90
8 in. by 50 ft.	22.65	20.30	18.00	20.30

10c. higher freight rates on account of double loads.
For plain pine poles, delivered New York, the price is as follows:

10-in. butts, 5-in. tops, length 20-30 ft.	$9.00
12-in. butts, 6-in. tops, length 30-40 ft.	11.50
12-in. butts, 6-in. tops, length 41-50 ft.	12.50
14-in. butts, 6-in. tops, length 51-60 ft.	21.00
14-in. butts, 6-in. tops, length 61-71 ft.	23.50

PIPE—The following discounts are for carload lots f. o. b. Pittsburgh, basing card in effect July 2, 1917, for iron, and May 1 for steel:

BUTT WELD

Inches	Steel Black	Galvanized	Inches	Iron Black	Galvanized
¼ to 3	49¢	35½¢	⅛ to 1½	33%	17¢

LAP WELD

2	42¢	29½¢	2	26%	12%
2½ to 6	45¢	32½¢	2½ to 4	28¢	15%
7 to 12	42¢	28½¢	4½ to 6	28¢	15%
13 and 14	32½¢		7 to 8	20¢	8%
15	30¢				

BUTT WELD, EXTRA STRONG PLAIN ENDS

¼ to 1½	47¢	34½¢	⅛ to 1½	33%	18¢
2 to 3	48¢	35½¢			

LAP WELD, EXTRA STRONG PLAIN ENDS

2	40¢	28½¢	2	27¢	14¢
2½ to 4	43¢	31½¢	9 to 12	15¢	3¢
4½ to 6	42¢	30½¢	7 to 12	25¢	12¢
7 to 8	38¢	24½¢	2½ to 4	29¢	17¢
9 to 12	33¢	19½¢	4½ to 6	28¢	16¢

From warehouses at the places named the following discounts hold for steel pipe:

	Black		
	New York	Chicago	St. Louis
⅛ to 3 in. butt welded	33%	42%	37¢
¾ to 6 in. lap welded	15¢	38%	33¢

	Galvanized		
	New York	Chicago	St. Louis
¼ to 3 in. butt welded	16%	26.9%	22%
3½ to 6 in. lap welded	+3	23.9%	19%

Malleable fittings, Class B and C, from New York stock sell at +5 from list prices. Cast iron, standard sizes, 10 and 5%.

BOILER TUBES—The following are the prices for carload lots f.o.b. Pittsburgh, announced Nov. 13, as agreed upon by manufacturers and the Government:

Lap Welded Steel		Charcoal Iron	
3½ to 4½ in.	34	3½ to 4½ in.	12½
2½ to 3¼ in.	24	3 to 3¼ in.	+ 5
2¼ in.	17½	2½ to 2⅝ in.	+ 7½
1¼ to 2 in.	13	2 to 2¼ in.	+22½
		1⅝ to 1¾ in.	+35

Standard Commercial Seamless—**Cold drawn or hot rolled**

	Per Net Ton		Per Net Ton
1 in.	$340	1⅝ in.	$220
1½ in.	280	2 to 2½ in.	190
1¼ in.	270	2¾ to 3¾ in.	180
1½ in.	220	4 in.	200
		4½ to 5 in.	220

These prices do not apply to special specifications for locomotive tubes nor to special specifications for tubes for the Navy Department, which will be subject to special negotiation.

ELECTRICAL SUPPLIES

ARMORED CABLE—

B.&S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$104.00	$138.00	$164.00	$222.00
No. 12 solid	135.00	170.00	211.00	290.00
No. 10 solid	185.00	235.00	255.00	325.00
No. 8 stranded	235.00	325.00	345.00	450.00
No. 6 stranded	370.00	472.00	625.00	.....

From the above lists discounts are:

	Net List
Less than coil lots	
Coils to 1,000 ft	10%
1,000 ft. and over	15%

BATTERIES, DRY—Regular No. 6 size red seal, Columbia, or Ever Ready:

	Each, Net
Less than 12	$0.40
12 to 50	.35
50 to 125 (bbl.)	.31
125 (bbl.) or over	.28

CONDUITS, ELBOWS AND COUPLINGS—Following are warehouse net prices per 1000 ft. for conduit and per unit for elbows and couplings:

	Conduit		Elbows		Couplings	
In.	Enameled	Galvanized	Enameled	Galvanized	Enameled	Galvanized
¾	$66.56	$71.66	$0.1602	$0.1716	$0.059	$0.0632
¾	87.75	94.65	.2108	.2258	.0843	.0903
1	129.71	139.91	.3119	.3341	.1096	.1174
1¼	175.49	189.29	.4019	.4289	.1518	.162
1½	209.83	226.33	.5358	.5718	.1875	.2001
2	282.31	304.51	.9823	1.05	.25	.2668
2½	446.36	481.46	1.61	1.71	.3572	.3812
3	583.70	629.60	4.28	4.57	.5358	.5718
3½	729.56	784.76	9.47	10.10	.7144	.7624
4	886.17	951.57	10.93	11.67	.893	.952

From New York Warehouse—Less 5% cash.

Standard lengths rigid, 10 ft. Standard lengths flexible, ½ in., 100 ft. Standard lengths flexible, ¾ to 2 in., 50 ft.

CONDUIT NON-METALLIC, LOOM—

Size I. D., In.	Feet per Coil	List, Ft.	
⅜	250	$0.05½	Coils...55% Off... Less coils, 40% off
½	250	.06	
¾	250	.09	
⅞	200	.12	
1	200	.15	
1¼	150	.18	
1½	100	.25	
1¾	100	.33	
2	Odd lengths	.40	
	Odd lengths	.55	

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.11	T. P. to D. P. S. B.	$0.24
D. P. M. L.	.18	T. P. to D. P. T. B.	.38
T. P. M. L.	.26	T. P. S. B.	.33
D. P. S. B.	.19	T. P. D. B.	.54
D. P. D. B.	.37		

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.33	$0.84	$1.68
T. P. M. L.	.48	1.20	2.40
D. P. S. B.	.42	1.05	....
T. P. S. B.	.81	1.80	....
D. P. D. B.	.78	2.10	....
T. P. D. B.	1.35	3.60	....
T. P. to D. P. D. B.	.90	2.52	....

FLEXIBLE CORD—Price per 1000 ft. in coils of 250 ft.:

No. 18 cotton twisted	$20.00
No. 16 cotton twisted	24.50
No. 18 cotton parallel	21.00
No. 16 cotton parallel	28.00
No. 18 cotton reinforced heavy	28.50
No. 16 cotton reinforced heavy	38.00
No. 18 cotton reinforced light	24.00
No. 16 cotton reinforced light	32.00
No. 18 cotton Canvasite cord	25.00
No. 16 cotton Canvasite cord	32.00

FUSES, ENCLOSED—

250-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	$0.25
35-amp. to 60-amp.	100	.35
65-amp. to 100-amp.	50	.90
110-amp. to 200-amp.	25	2.00
225-amp. to 400-amp.	25	3.60
450-amp. to 600-amp.	10	5.50

600-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	.40
35-amp. to 60-amp.	100	.60
65-amp. to 100-amp.	50	1.50
110-amp. to 200-amp.	25	2.50
225-amp. to 400-amp.	25	5.50
450-amp. to 600-amp.	10	8.00
Discount: Less 1-5th standard package	30%	
1-5th to standard package	40%	
Standard package	52%	

FUSE PLUGS, MICA CAP—

0-30 ampere, standard package	$4.20 C
0-30 ampere, less than standard package	5.00 C

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs				Pear-Shape Bulbs			
Mazda B—			No. in	Mazda C—			No. in
Watts	Plain	Frosted	Package	Watts	Clear	Frosted	Package
10	$0.30	$0.33	100	75	$0.70	$0.75	50
15	.30	.33	100	100	1.10	1.15	24
25	.30	.33	100	150	1.65	1.70	24
40	.30	.33	100	200	2.20	2.27	24
50	.30	.33	100	300	3.25	3.35	24
60	.35	.39	100	400	4.30	4.45	12
100	.70	.77	24	500	4.70	4.85	12
				750	6.50	6.75	8
				1000	7.50	7.75	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $150 to $300,000 net allow a discount of 17 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Hubbell, porcelain No. 5406, standard package 250	$0.21
Hubbell composition No. 5467, standard package 50	.28
Benjamin swivel No. 903, standard package 250	.15
Hubbell current taps No. 5638, standard package 50	.35

RUBBER-COVERED COPPER WIRE—Per 1000 ft. in New York:

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$12.00	$14.00	$16.00	$27.00
12	14.23	16.92	19.48	32.25
10	16.92	22.83	25.81	45.00
8	27.65	31.40	35.50	61.00
6	.....	.....	56.00	.....
4	.....	.....	76.40	.....
2	.....	.....	112.45	.....
1	.....	.....	152.26	.....
0	.....	.....	182.90	.....
00	.....	.....	223.63	.....
000	.....	.....	271.24	.....
0000	.....	.....	332.40	.....

Prices per 1000 ft. for Rubber-covered Wire in Following Cities:

	Denver			St. Louis			Birmingham		
No.	Single Braid	Double Braid	Duplex	Single Braid	Double Braid	Duplex	Single Braid	Double Braid	Duplex
14	$15.00	$20.00	$35.00	$21.00	$16.00	$33.00	$11.50	$17.80	$36.30
12	25.65	26.90	57.45	27.20	31.00	69.00	31.80	34.30	67.60
8	36.45	40.25	80.30	38.00	42.00	78.00	42.85	46.85	.....
6	57.40	61.70	.....	.....	65.00	130.00	69.60	74.10	.....
4	83.40	88.70	.....	.....	93.00	.....	101.75	151.55	.....
2	126.60	132.80	.....	.....	140.00	.....	151.50	168.00	.....
1	164.15	172.40	.....	.....	182.00	.....	201.00	254.50	.....
0	206.80	206.80	.....	.....	242.00	.....	276.00	285.00	.....
00	278.80	278.80	.....	.....	290.00	.....	317.00	330.00	.....
000	341.65	341.65	.....	.....	360.00	.....	417.00	428.50	.....
0000	417.05	417.05	.....	.....	435.00	.....	507.00	516.04	.....

SOCKETS, BRASS SHELL—

⅛ In. or Pendant Cap.			¾ In. Cap		
Key, Each	Keyless, Each	Pull, Each	Key, Each	Keyless, Each	Pull, Each
$0.33	$0.30	$0.60	$0.39	$0.36	$0.66

Less 1-5th standard package	+10%
1-5th to standard package	+ 8%
Standard package	−25%

WIRE, ANNUNCIATOR AND DAMPPROOF OFFICE—

No. 18 B.&S. regular spools (approx. 8 lb.)	46c. lb.
No. 18 B.&S. regular 1-lb. coils	47c. lb.

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 40c. lb., 100 lb. lots	38c. lb.
Rubber tape, ¾ in., less 100 lb., 48c. lb., 100 lb. lots	45c. lb.
Wire solder, less 100 lb. 50c. lb., 100 lb. lots	46c. lb.
Soldering paste, 2 oz. cans Nokorode	$1.20 doz.

SWITCHES, KNIFE—

TYPE "C" NOT FUSIBLE

Size, Amp.	Single Pole, Each	Double Pole, Each	Three Pole, Each	Four Pole Each
30	$0.42	$0.68	$1.02	$1.36
60	.74	1.22	1.84	2.44
100	1.50	2.50	3.76	5.00
200	2.70	4.50	6.76	9.00

TYPE "C" FUSIBLE, TOP OR BOTTOM

30	.70	1.06	1.60	2.12
60	1.18	1.80	2.70	3.60
100	2.38	3.66	5.50	7.30
200	4.40	6.76	10.14	13.50

Discounts:

Less than $10.00 list value	5%
$10 to $25 list value	16%
$25 to $50 list value	24%
$50 to $200 list value	28%
$200 list value or over	31%